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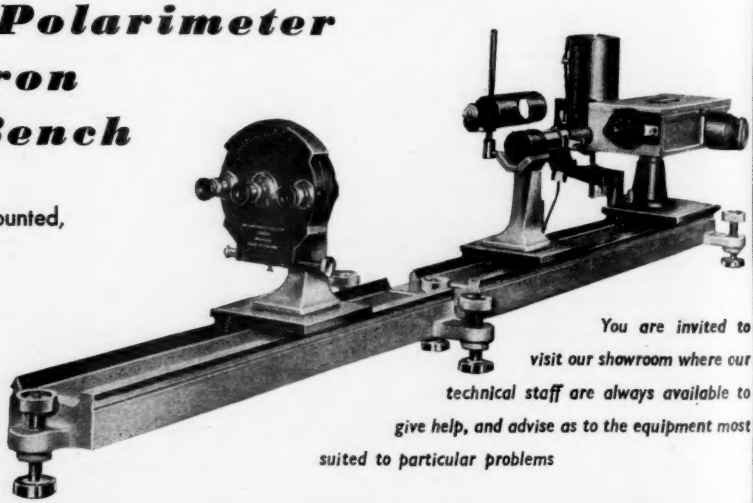

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HIGHER TECHNICAL EDUCATION IN BRITAIN

THE debate on higher technical education on Tees-side, which Mr. H. A. Marquand initiated in the House of Commons on the adjournment on March 29, was not reassuring to those who believe that, in spite of the care taken in the White Paper to distinguish between technical and technological education, the proposal to raise to colleges of advanced technology of university standard some twenty-four or more of the existing technical colleges which receive 75 per cent grant for certain of their advanced work, is likely to spread available man-power and money too thinly. Mr. Marquand, in pressing the claims of the Tees-side area for a college of technology, challenged in the first instance the regional distribution. Eleven of the colleges it is proposed to advance are in the London area, and only five, apart from the Manchester College of Technology, which is not included in the count, are in the north of England. Mr. Marquand said quite rightly that a much larger proportion of the industry of Great Britain is to be found in the north than is suggested by these figures, and it is obviously wise, in planning the extension of technological and technical education, particularly with sandwich courses in mind, to pay a good deal of attention to the location of industry.

This applies particularly to technical education, and thus far the argument is sound. Mr. J. E. S. Simon, in supporting Mr. Marquand's argument for the development of Constantine College, Middlesbrough, as a regional college of technology for the Tees-side area, suggested that besides this question of balanced distribution, location should also be determined by the existence in the area of a tradition of craftsmanship, and the attitude of local authorities, employers and trade unions. These may well be more important than the last factor to which Mr. Simon referred, namely, the existence of an efficient technical college capable of expansion. The presence of such a college may well, as the debate showed, engender questions of local prestige and involve difficult decisions as to the location of technical and technological education, which are not always carried on with full efficiency in the same institution.

Mr. Arthur Palmer, member for Cleveland, also urged that chemical developments on Tees-side as well as the expansion of other industries, especially steel-making, make a technological institution of the highest standard desirable on Tees-side; and Mr. David Jones, member for the Hartlepools, agreed that in the Constantine College, Middlesbrough, there is the makings of an institution well situated to meet the needs of the area. The Parliamentary Secretary to the Ministry of Education, Mr. D. Vosper, in replying for the Government, agreed that such considerations should be taken into account and, more specifically, said that the Minister would bear in mind the large developments on Tees-side when deciding which additional colleges should be recognized as colleges of advanced technology. Mr. Vosper reiterated that other colleges besides those named in the White Paper might qualify for the 75 per cent grant, and he explained at some length why the Constantine College had not been named in the White Paper.

Much more important, however, was Mr. Vosper's indication that the White Paper on Technical Education is to be debated in full, when the Minister hopes to elaborate the position of the colleges of advanced technology, and his admission that we must ensure that our limited resources are not spread too thinly. In this welcome admission, Mr. Vosper had particularly in mind the teaching staff, and it is something that the Government should at last recognize that the supply of qualified teachers for advanced work is limited and must therefore be used to the best advantage by building up units of reasonable size. We must not try to provide too many or too varied courses in any particular place.

That, of course, is the real indictment of the Government's proposals as set out in the White Paper, coupled with anomalies such as the treatment of the College of Technology, Manchester, the Imperial College of Science and Technology, and the Royal Technical College, Glasgow, separately from other technological institutions. If the resources for technological education in Britain are to be deployed to the best advantage, they must be planned as a whole, whether training is given in a university department or in a college of technology. The responsibility must be placed fairly and squarely on some one authority, and if this cannot be borne by the University Grants Committee, an appropriate body must be created for the purpose.

Mr. Vosper's reply on March 29 indicates how far the Government has yet to go in facing the realities of the situation; nor did Mr. Vosper give any indication that the Minister of Education is likely to grapple with the problems that parochial rivalries will engender for an adequate regional plan for not more than a dozen colleges of technology where higher technological education is given under appropriate conditions of teaching and research. Those issues cannot be avoided, and the earlier they are faced and tackled the more likely we are to secure the understanding, goodwill and co-operation which have marked the relinquishing of local control over the College of Technology in Manchester. Moreover, if the issue is grasped with imagination and the expansion of technical education is tackled with the energy and understanding as well as on the scale it demands, there should be little chance of any local dissatisfaction that a particular technical college has not been raised to a college of technology.

It should be emphasized, in fact, that the difference between a college of technology and a technical college, between technologist and technician, is qualitative, and not one of social status. We need

many more technicians than technologists ; but their work is just as important and satisfying, and the idea of inferiority should be attacked wherever it displays itself. It is the difference in the nature of the instruction to be given and the conditions required that make it difficult for justice to be done to both types of training within the same institution. It is to be hoped that the forthcoming debate will force the Government to declare itself much more fully about its proposals for the expansion of technical education, that is, the training of technicians, than it has done in the White Paper.

It would appear improbable that in the forthcoming debate the plans of the universities over the next quinquennium for technological education will be made known ; and until those plans are revealed, the adequacy of the Government's proposals for the expansion of technological education cannot be assessed. What needs to be emphasized now is that we are most likely to develop the resources of Britain to the best advantage if technological education, if not technical education also, is placed under the responsibility of one body of the standing of the University Grants Committee. Not only Dr. Venables in his recent book, but also Lord Waverley, at the annual luncheon of the Parliamentary and Scientific Committee on February 27, and others, have strongly pressed this view.

Financing the colleges of technology on a basis similar to that established under the University Grants Committee would give the colleges the status and independence which would help to attract staff of the highest ability ; and the principle of quinquennial grants would greatly facilitate the undertaking of research on an adequate scale. Even more important, the standing of such a body would give its recommendations on technical education as well as technological education an authority which the Minister of Education could not ignore, and which should strengthen his hand in dealing with those authorities who, for any reason, were unwilling or unable to co-operate or maintain the standards which the national interest indicates. Technical and technological education cannot be sharply separated ; but a body of this character would be well placed to indicate ways and means which would avoid placing on local authorities responsibilities they should not fairly be expected to meet from local funds.

While, however, the Government hesitates and, lacking the courage to deal with the real difficulty, has called into being what Dr. D. S. Anderson terms an entirely unnecessary body in the National Council for Awards in Technology, there is a remarkable unanimity of opinion among those best qualified to judge the needs of both technological and technical education in Britain. Dr. Anderson, addressing the Northern Counties Technical Examinations Council on February 11, emphasized the importance of sandwich courses. Like Dr. Venables, he believes these will be the major development of the next decade ; but, unlike the White Paper, he detailed the conditions which should be met before an institution can efficiently participate in such schemes. These conditions would limit potential ultimate expansion to some twenty institutions at most, if the scheme was to lead to an award recognized as at least equivalent to a university degree. Moreover, Dr. Anderson pointed to the value of the co-operation to be obtained from the professional institutions, which the Government has ignored, as well as to the importance of greater co-operation with industry ; and he stressed particularly the possibilities of making greater use of the staffs of technical colleges for consulting work and also the importance of making opportunities, by shorter sessions and a longer summer vacation, to keep up to date and maintain closer contact with industry.

These are not simple problems ; but they should not be ignored and left unsolved as the Government proposes. Moreover, the release of teachers to return to industry and be brought up to date in the latest manufacturing technique is related to such problems as the education of older engineers which was discussed last January at a joint meeting of the Institutions of Civil, Mechanical and Electrical Engineers. Since the Second World War, the number of postgraduate courses available not only for engineers, but also for chemists, physicists and others, has greatly increased, and they are probably provided by most universities and colleges of technology in Britain. It does not appear, however, from either the papers presented or the subsequent discussion, that we have yet learned the best ways of presenting such courses, or are able to assess the real value of such short courses compared with the university or technological course of, say, six months duration. Nor is it clear where such courses are best organized.

The answers to such problems involve questions about the release of staff on both sides, or even its transfer from industry to the colleges of technology or vice versa, and much more critical and constructive thinking must be given to them if the essential co-operation from industry is to be secured. The point to be emphasized here is that the conditions created in both colleges of technology and the technical colleges by the proposed expansion should be such as to facilitate these developments and make the interchange and release of staff easier and not more difficult. Nor is it simply that postgraduate courses are designed to provide industry's leavening of men capable of technical leadership and really advanced thinking with the opportunities of advanced theoretical study they require. They are also part of the means of disseminating rapidly throughout industry knowledge of the latest techniques of design and knowledge.

In this sense both technical colleges and colleges of technology in Britain must form part, if not the nucleus, of a public technical information service. They cannot, however, add this to their primary function of teaching, if not of research, unless they are adequately equipped. The plain truth is that, as was pointed out in a memorandum recently prepared by the Library Association to the Scientific and Technical Information Committee of the Advisory Council on Scientific Policy, and is amply confirmed by the returns from the University Grants Com-

mittee, there is scarcely a major technological institution in Britain that is at present adequately equipped to render the library service alone that its own staff and students need. Standards not merely of equipment and in the provision of space for readers but also of expenditure on books and periodicals need to be expanded, quite apart from any prospective increase in the present number of students, before the colleges of technology or technical colleges can hope to make any useful contribution to the regional technical library and information service that admittedly is required to further the more effective utilization of existing knowledge.

This is only one respect in which the Government's present proposals are unrealistic and appear to pay insufficient attention to what needs to be done to raise the standards of even a dozen institutions in Britain to enable them to give efficient regional service in respect of teaching, research and the dissemination of information. There are other respects in which more could be done to eliminate waste and secure the full use of existing facilities. Nothing that the Prime Minister said to the Parliamentary and Scientific Committee on February 29 removed such misgivings. Sir Anthony Eden repeated that it is the intention to increase the output of 'technologists' from some twenty or more technical colleges by fifty per cent, and that these colleges must have a high status and be as independent as possible. He did not indicate, however, where the necessary qualified staff is to be obtained; nor did he enlarge on the plans to expand the output of technicians and craftsmen from the other technical colleges. Until such plans are indicated more precisely, it is probable that the more nearly the Government's proposals to produce another 2,500 technologists a year succeed, the more serious will be the effect on the output of supporting technicians and craftsmen.

There are thus numerous points on which the Government should be pressed to elaborate its plans and to modify the proposals set forth in the White Paper. But there are some hopeful features of the situation. The Industrial Fund for the Advancement of Scientific Education in Schools, already within sight of its financial target of £3·5 million, should contribute to encourage more boys and girls to take up careers in science, provided that full use is made of the new special responsibility allowances and other measures to deal with the shortage of science masters. The scholarship scheme recently endowed by Imperial Chemical Industries to enable school children who have taken arts subjects at school to enter the universities to train as scientists should, like the scheme announced last year for the University of Liverpool, and the preliminary science course at the Imperial College of Science and Technology, enable more school leavers to transfer from arts to science. Among the best proposals in the White Paper are those which will permit State scholarships to be held for courses leading to awards in technology. There is still room, however, for other universities and for local education authorities to promote these trends by their own action, and it should be borne in mind that a similar scheme at University College, Oxford, met with so disappointing a response that no award could be made.

Moreover, at the other end, to which also Dr. Anderson referred, the concern of technical colleges with training for management is checking excessive specialization and encouraging the broad education, stressed alike in the White Paper and more recently at the Conference of the British Institute of Management and the Institute of Industrial Administration at Southport during March 20–21. We need, as Mr. D. R. O. Thomas urged there, men who can evaluate the significance of technology and science, who are responsive to ideas over a wide front and are capable of accepting responsibility and acting with courage and decision. We need also technicians and craftsmen who appreciate the significance of change and are ready, as well as competent, to adopt new techniques and products; and it should be noted that at the annual conference of the National Association for the Advancement of Education for Commerce, Mr. J. P. Jones's plea for liberal studies in technical courses found general support.

Perhaps the best feature of the discussion now proceeding on the expansion of technical and technological education in Britain is that it contributes to a fuller public understanding of all that is involved. Such understanding is essential if we are to secure for the technical college the amenities which Dr. Anderson rightly stressed as indispensable to enable it to fulfil its real function. It is equally essential in order to ensure that the expansion of technological education is carried out not as something apart, but as one element in the development of the whole education system of Britain, to equip the youth of the nation to play its fitting part in the age of nuclear energy, of the automatic factory and of other rapid technical changes on which the world is entering. That at least is what is implied in any action to give effect to recommendations which may come in due course from the Crowther Committee set up on March 2.

BIOCHEMICAL GENETICS

Genetics and Metabolism

By Robert P. Wagner and Herschel K. Mitchell. Pp. xi+444. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1955.) 60*s*. net.

IT is probable that within the next generation the science of genetics may split. If so, one branch will perhaps unite with biochemistry. It will be concerned with processes which are understood at the molecular level. For example, what is now called crossing-over will probably be called transphosphorylation in nucleic acid chain molecules, and what is now called mutation will turn out to consist of several rather disparate processes. Another section will deal with developmental processes not yet reduced to biochemistry, and a third with the genetics of populations.

The book under review can be thought of as a pioneer exposition of the unified sciences of biochemical genetics and dynamical biochemistry. The

authors are best known for their work on *Neurospora*, and Chapters 5 and 8, which are mainly concerned with this fungus, are particularly good. The book can be read by a student who does not know very much biochemistry or genetics; for it attempts to describe cellular structure, and the nature of enzymes and genes, and ends up with the discussion of a number of developmental questions, including the very fundamental one of 'self-duplicating' units outside the nucleus. Were it not for its price, I should recommend it to every student of biology.

It is so good that I have little doubt that a new edition will soon be needed, and it is therefore constructive to point out what seem to me to be defects in it. The discovery of the yellow anthochlor pigments derived from benzalcoumarone by Geissmann and his colleagues should have been included in Chapter 4, much of which was out of date when written. The treatment of human genetics is inadequate, particularly as this branch of genetics furnishes so many striking examples of conditions due to the absence of a specific enzyme, such as acatalasæmia, phenylketonuria and, more recently, galactosæmia. Again, human blood may fail to coagulate owing to the lack of any of six different proteins, each of the syntheses of which is controlled by a different gene. Most of them do not seem to be enzymes, in the ordinary sense of that word, and they are perhaps a model for systems which will later be discovered within cells. The account of the metabolism of homogentisate refers to no work since 1914, nor does that of the blood group antigens describe the work either of Morgan and his colleagues, or of Kabat and his colleagues, on their composition.

As I know to my cost, the compilation of a book on this subject involves very wide reading of periodicals, and the above criticisms are made in sympathy rather than malice. To sum up, the book was badly needed, and I hope that it will be widely read. But just because it is a pioneering effort, it lacks some of the balance and completeness which are to be expected in texts on a topic that has been systematically taught for some decades.

J. B. S. Haldane

A NEW SYNTHESIS OF SPECIAL RELATIVITY

Relativity

The Special Theory. By Prof. J. L. Synge. (Series in Physics.) Pp. xiv+450. (Amsterdam: North-Holland Publishing Company, 1956.) 38 florins; 76*s*.

THIS notable book was originally planned to cover both the special and the general theories of relativity, but the special theory developed in such a way that, in the end, the general theory had to be omitted. The evident enjoyment with which it was written conveys itself to the reader, and even the sections dealing with the more classical parts of relativity show something of the excitement of fresh discovery. The book represents a breakaway from traditional modes of presentation. Here are no trains, or embankments, or lightning-flashes striking rails, or even the Michelson–Morley experiment except as an incidental. Neither is there a formal series of postulates and theorems designed to display logical self-consistency. Hypotheses are clearly stated as the need for them arises, and points of logical, physical or philosophical difficulty are never shirked, self-consistency thereby being made apparent without fuss. Prof. J. L. Synge, remarking that the purpose of a mathematical model is to assist in the exploration of Nature, expresses the opinion that "a theory in mathematical physics is to be judged primarily on the basis of its logical consistency and only secondarily on the basis of the truth of its physical predictions", both Newtonian and relativistic mechanics being thus unassailable as mathematical models. With that doctrine one may well agree provided a given model does, in fact, fulfil the stated purpose.

The basic plan of the book is to utilize four-dimensional geometrical ideas to the full, while keeping their physical meaning and description always in mind. The essential properties of Minkowskian four-space in relation to physical concepts are established in the first three chapters with a clarity characteristic of the author. This is followed by a full and fresh account of the Lorentz transformation and its physical significance. Here and afterwards the switch from the geometrical to the physical description, and vice versa, is constantly and illuminatingly made. A consequence is that, for all its comprehensiveness, the book is perhaps more suited to mature readers than to beginners in this field.

Nothing much short of a page-by-page account of the author's arguments, methods and results could do full justice to an interesting and lively book. After a chapter on the mechanics of a particle, including collision and disintegration problems, he proceeds to the mechanics of a discrete system. Here, in order to obviate the difficulty caused by the absence in relativity of a law of action and reaction except for particles in direct contact, he uses his own tentative theory of "internal impulses", these being hypothetical entities, possessing energy and momentum, which the physical particles of the system are supposed to fire at one another. Applied to two particles only, with a single internal impulse shuttling between them, the inverse-square law emerges as a first approximation when the relative speeds of the particles are small compared with that of light. This remarkable deduction of the inverse-square law may cause the reader to raise an admiring or a sceptical eyebrow according to his prejudices. Prof. Synge himself expresses no more than interest coupled with a doubt about the general validity of his scheme for physics as a whole.

From the mechanics of a discrete system he passes to that of a continuum by using statistical methods. This leads to the introduction of the energy tensor and to the macroscopic theory. The remainder of the book is devoted to electromagnetism, and contains a great deal of both mathematical and physical interest, including wave theory. A particularly interesting section is devoted to electromagnetic shock-waves.

But, it may be asked, is all of this properly described as special relativity? It comes very near to being a general theory in which physical phenomena are mapped upon a flat Minkowskian four-space instead of upon a curved space as in general relativity proper. It is admittedly a theory in which Lorentz invariance is the dominating feature, and this does perhaps legitimize its description as special. It may be hoped that the second volume on general relativity, promised by the publisher on the dust-cover, will in fact appear, for the present volume stimulates an appetite for more. The foundations of a further

volume are here laid by a consistent use of tensor and geometrical methods.

The book is full of wise saws and modern instances, all eminently quotable if space did but permit. It is cheerful in style, profusely illustrated by diagrams, and beautifully printed. That its author himself directs attention to the debatable nature of some of his work in no way lessens its interest, but on the contrary makes it all the more stimulating. The pure mathematics in it is alone sufficient to make it an important contribution to the literature of relativity.

H. S. RUSE

THE ORIGINS OF INTELLECT

The Child's Construction of Reality

By Prof. Jean Piaget. (Translated from the French by Margaret Cook.) Pp. xiii + 389. (London : Routledge and Kegan Paul, Ltd., 1955.) 25*s*. net.

THIS is a companion volume to Prof. J. Piaget's earlier book on "The Origins of Intelligence in the Child" and should be studied in close connexion with it. In his earlier work, Prof. Piaget aimed to define the processes by which the young child comes to create an external world ; in the present volume, he devotes his attention more specifically to the nature of the world created. In short, we are now concerned with the products of the child's thinking rather than with the thought processes themselves. None the less, the two aspects—subjective and objective—are so closely related that an independent treatment of either is scarcely possible. For this reason, it is necessary to consider the two books essentially as one.

The growth of the child's conception of external reality is treated by Prof. Piaget under four main aspects : first, the development of object-concepts and the correlated treatment of objects as being both individual and permanent ; secondly, the evolution of a spatial framework common to all sensory modalities ; thirdly, the development of ideas of causal relationship ; and fourthly, the organization of a temporal field endowing external events with some measure of coherence. These four processes, which are of course closely inter-related, are supposed by Piaget to develop through a series of well-marked stages, and his main task in the present book is to reconstruct the nature of the child's world at each stage. In some measure he would appear to succeed. The main theoretical conclusions derived from the two studies are brought together in a final section of this volume.

Although Prof. Piaget's systematic psychology is difficult, and at times obscure, his work brings out a number of points of the highest interest and importance. For example, his careful observations of the earliest reflex patterns make it clear that some measure of adaptation of response to the finer characteristics of the stimulus field appears to be present *ab initio*. This makes possible a theoretical treatment of reflex action much less rigid and mechanistic than is *de rigueur* in present-day psychology, and permits an altogether easier transition from the more to the less automatic varieties of behaviour. Again, Prof. Piaget's treatment of spatial perception clearly brings out that this activity, from a genetic point of view at least, cannot be considered apart from the study of movement. Space, as he rightly points out, is an organization of movements such as to impose upon perception spatial relations that are increasingly precise and coherent. More generally, space may be regarded as a product of interaction between the organism and the environment in which it is impossible to dissociate the content perceived from the motor activity of the percipient. Although statements of this kind are perhaps too broad to convince, they serve at least to focus attention upon the role of action in the growth of our knowledge of the external world. Prof. Piaget's evidence may also be of great value to neurologists and others interested in the breakdown of spatial perception in abnormal states of the central nervous system.

Although Prof. Piaget bases his arguments throughout on empirical considerations, it cannot be said that the material presented in this volume possesses any great evidential value. It consists in the main of some two hundred observations—some little better than anecdotes—which the author has made on three young children (presumably his own), and no attempt is made to confirm the findings by means of appropriate large-scale inquiry. Indeed, many of these observations, despite their undoubted perspicacity, do little more than provide apposite illustrations of the author's theoretical contentions. Examples have great value so long as they are not confounded with evidence. Can we be quite sure that Prof. Piaget is himself free from this source of confusion ?

This book is original and thought-provoking. Prof. Piaget is perhaps the last of the great psychological system-builders. Although a whole host of empirical researches have been woven into the fabric of his system, it remains at bottom personal, speculative and unverifiable. It is not science, but it may well be the necessary precursor of a scientific psychology.

O. L. ZANGWILL

ARRESTED GROWTH IN ARTHROPODS

The Physiology of Diapause in Arthropods

By Dr. A. D. Lees. (Cambridge Monographs in Experimental Biology—No. 4.) Pp. x + 151. (Cambridge : At the University Press, 1955.) 12*s*. 6*d*. net.

THE periodic arrest of growth or reproduction that is so characteristic of the life of arthropods in temperate latitudes forms one of those subjects which provide problems of the greatest theoretical interest and at the same time are of much practical importance to the applied biologist and the farmer. As his title implies, in this latest volume in the Cambridge Monographs in Experimental Biology Dr. A. D. Lees is concerned primarily with the more fundamental aspects of diapause : the physiological nature of the arrest and the ways in which its timing is regulated to fit in with the possibilities of life at each season. At one time diapause was regarded primarily as a state of subdued metabolism. Then it came to be thought of rather as an arrest of growth, the reduced metabolism being secondary ; and when growth in the insect was shown to be dependent upon the secretion of hormones, the theory was put forward by Wigglesworth that the immediate cause of diapause was a failure in this secretion. By and large that conception has been supported by experiment : in the pupa in diapause the neurosecretory cells in the brain are inactive.

But many insects, during the summer months, can pass through a number of generations without any arrest. With the approach of autumn diapause supervenes. By what token does the insect know that winter is coming? During the past few years it has been shown, in a wide range of species, that the absolute day-length is the most important sign: as soon as the light period is reduced to twelve or thirteen hours diapause supervenes. Falling temperature and reduction in the nutritional value of the foliage are important in varying degrees in different species; in some these factors may override the effect of day-length. It is also interesting to note that in at least one insect, the larva of a dragonfly, the *change* in day-length after the summer solstice is the important factor. What is still obscure is the nature of the connecting links between the duration of illumination and the inactivation of the neurosecretory cells in the brain. Presumably some photochemical reaction is the first step. The papers dealing with this rapidly developing subject are many of them scattered among the Russian and Japanese journals. One of the most valuable features of Dr. Lees's book is that all this material is critically assessed for the first time.

Since the classic researches of Ducleaux it has been known that a more-or-less extended period at a very low temperature is necessary in order to 'break' diapause and to bring the insect to a state when it can once more develop in a favourable environment. This apparently mysterious change has been put in a proper perspective by the work of Andrewartha, who has pointed out that this progressive change is affected by temperature just like any other physiological process; but that it has an unusually low temperature optimum, usually around 5° or 10° C. The nature of this process, sometimes called 'diapause development', is still obscure.

All these matters, as described by Lees, make a fascinating story, closely argued and well written.

MINERAL DRESSING

An Introduction to Mineral Dressing

By E. J. Pryor. Pp. xii+649. (London: Mining Publications, Ltd., 1955.) 70*s*.

THIS, the first text-book on mineral dressing to be published in Great Britain since 1923, is based upon the elementary course in mineral dressing given to students of the Royal School of Mines, London. It is good in its conception and in much of its execution, especially the general lay-out and arrangement of subject-matter. Criticisms in this review are intended to be read in the light of the essential quality of the book; they are also intended to direct attention to shortcomings which, it is hoped, will be rectified in a second edition that the book well deserves.

It contains a very great deal of information, much more than might be expected in an introduction to the subject; indeed, in some sections, the author goes into great detail, much of it unnecessary and possibly disconcerting to those taking an elementary introductory course. Such people are, or should be, concerned with principles—as the author implies on p. 2. It seems out of place in an introduction of this sort to discuss, as the author does in places, details of what the alert [*sic*] shiftsman should do in controlling a mineral dressing plant; such details properly belong to practical application of principles.

The style in places is somewhat pedantic; this may sometimes lead to a confusion in the mind of the reader, who may find it necessary to read some parts two or three times to be certain of what the author means. It may, perhaps, be unfair to select part of one paragraph to illustrate this, but the following three consecutive sentences which appear in the first chapter could well have been more simply expressed: "A problem in physics can be analysed, as Einstein shows, into three phases—the event, its signal and the effect produced on the observer. Basic technology, as used in mineral-dressing research, seeks to influence the nature of the signal, either by initiating the event or steering its course, and then by substituting for the observer a piece of apparatus which reacts specifically to the signal. With controlled initiation of noumenon, distinctive quality in phenomenon, and unilateral separatory reaction, applied technology steps in". These, and other similar descriptions, could deter a timid reader.

In the quotation made above the term 'mineral dressing' has a hyphen; elsewhere in the book it has not. This is typical of lack of attention to detail in writing. There is no uniformity in abbreviations; *foot* may appear as foot, ft. or ′; *specific gravity* may be written in full or as sp. gr., s.g., or S.G. The word *pennyweights* is given three different abbreviations; the British Standard series of sieves is referred to in different places as the B.E.S.A., the B.S.I., or the B.S. series; other terms have two different abbreviations. The terms gravity, specific gravity and density (no units expressed) are used interchangeably; an example of this occurs in Table 12, where one part of the table is headed: "Bath S.G. = 2·70"; the other part is headed: "Bath Density = 2·80". The value of surface tension for water is given as 72·3 dynes instead of dynes per cm.; no temperature is stated. There are many more examples of this lack of attention to detail.

It is surprising to find in this book, where Brownian motion is called pedesis, that space is devoted to explaining the significance of the suffixes *-ous* and *-ic*, as in ferrous and ferric, and that sodium hydroxide is called sodium hydrate. But perhaps the most remarkable feature of the book is the almost complete absence of mathematical approaches and explanations. One or two formulæ are given; but the author could have made some of his explanations much simpler if he had used mathematical aids. Less than a quarter of the 233 figures have captions. Some of the figures are poor and include numbered or lettered parts which are not referred to in the text.

The inclusion of a glossary of terms is good, but the glossary is spoilt by incompleteness and by the seemingly haphazard way in which items have been selected for inclusion; for example, the word 'flotation' is included, but not 'flocculation'. Similarly, the index is incomplete; for example, the Chance process is included, but not the Rheolaveur.

Inadequate attention to details of presentation detract from a book which could well have been outstanding. The general method of presentation is commendable. It is to be hoped that there will be a second edition in which uniformity is ensured, in which certain sections (especially those on the physics and chemistry of pulps and on coal cleaning) are improved and from which details of plant operation are omitted.

S. G. Ward

An Introduction to the Electronic Theory of Valency

By Dr. J. C. Speakman. Third edition. Pp. vii+180. (London: Edward Arnold (Publishers), Ltd., 1955.) 10*s*. 6*d*. net.

OUR ever-increasing knowledge of the structure of molecules and of the bonding of the component atoms not only expands the meaning of the term 'valency' but also makes a text-book account of it difficult to write. The second edition of Dr. J. C. Speakman's well-known introduction to the subject was published in 1943, and it is not surprising that he has now drastically revised it. In the new edition, he has changed the word 'modern' of the title to 'electronic' and has divided his work into two parts. The four chapters forming Part 1 deal, at sixth-form level, with the three chief types of bonds, and the treatment is but little changed from that in the second edition.

Part 2, however, he has almost completely rewritten. In a new chapter (5), without the use of any mathematics, Dr. Speakman has essayed to expound, in what he calls "a pictorial and descriptive way", the molecular configuration of electrons both from the valency-bond and from the molecular-orbital approach. The titles of Chapters 6–11 remain unchanged, but the subject-matter has been rewritten from the modern point of view. The hydrogen bond now gets six pages. Chapter 12 contains an interesting discussion of the meaning of the term valency and of the present-day position of the concept.

Throughout Part 2 Dr. Speakman, while admitting difficulties, apparent contradictions and conflicting views, is temperately critical and nowhere dogmatic. Implicit in his attitude to the subject is the advice to accept approaches to truth for their usefulness and not to let ideas on valency crystallize. His book is a praiseworthy attempt to give a simplified account of the present-day position of this concept.

G. FOWLES

Annuaire pour l'An 1956

Publié par le Bureau des Longitudes, avec un Supplément pour l'An 1957. Pp. viii+729. (Paris: Gauthier-Villars, 1956.) n.p.

THE "Annuaire" for 1956 of the Bureau des Longitudes, together with a supplement for the year 1957, consists of tables, definitions and articles contained on 614 principal and 121 supplementary pages, and several additional folding diagrams illustrative of the text.

The Bureau des Longitudes, constituted on June 25, 1795, by the then French National Convention, consists of fourteen members and six additional members, all of them French nationals, together with thirty internationally distinguished correspondents, not necessarily of French nationality (three are British). It is charged with making recommendations for the improvement of the different branches of astronomy and their application to geography, navigation and the physics of the Earth, and it is responsible for five other regular publications in addition to the "Annuaire".

The present "Annuaire" covers the following subjects: calendars—the principal world calendars and astronomical data associated with them, and tides; geophysics—the data of meteorological, atmospheric electricity and terrestrial magnetic phenomena; time—astronomical data concerning the Sun, Moon, major planets, comets and certain stars; tables of weights and measures; and physical and chemical constants. The articles are "Radioélectricité et opérations mondiales des longitudes", by B. Decaux, and "Les récepteurs photoélectriques", by A. Lallemand.

A Short History of Medicine

By Prof. Erwin H. Ackerknecht. Pp. xviii+258. (New York: The Ronald Press Company, 1955.) 4.50 dollars.

DR. ACKERKNECHT, an accomplished scholar, is professor of the history of medicine in the University of Wisconsin. He has here set himself to provide medical practitioners with a short and simple account of the development of their art and has succeeded admirably. The work is concise and well balanced; but perhaps its most outstanding feature is the exceptional skill shown in treating the very intricate developments of the first half of the twentieth century—precisely the period where most such short histories tend to fail. This last chapter is so well done that many practitioners will find the volume a useful reference desk-book which they may conveniently consult for the dates, circumstances and authors of the main modern treatments and remedies. The historical perspective is well maintained throughout though, in my opinion, later editions would gain by condensing or telescoping the pre-Greek medical systems. These are of great interest and are well treated; but their bearing on scientific medicine is too remote to appeal to the audience for which this book is so particularly well designed. Further space might be saved on illustrations, the selection and reproduction of which show less of the care lavished on the text. These are minor and easily reparable faults in a work which I would heartily recommend.

CHARLES SINGER

Stratigraphic Geology

By Maurice Gignoux. English translation from the Fourth French Edition, 1950, by Gwendolyn G. Woodford. (Series of Geology Texts.) Pp. xvi+682. (San Francisco: W. H. Freeman and Company; London: Bailey Bros. and Swinfen, Ltd., 1955.) 9.50 dollars; 80*s*.

THE "Géologie stratigraphique" of Maurice Gignoux has been justly famous as an excellent exposition of stratigraphy as seen from the French point of view. Now that its fourth edition has been translated, it has become available to those who prefer to read it in English. The book has not changed its character as a result of G. G. Woodford's successful effort (translations of this kind are notoriously difficult); it has remained intensely French. There is the elegant and didactically effective method of dealing with typical areas in detail, leaving the rest of the world to a generalized treatment. Most examples have been taken from France, and the Alps have received special attention. Herein lies the chief value of the book for the English-speaking reader.

Similarly, references are particularly numerous for France and French territories, especially North Africa. In this edition, the questions of the Sahelian and of the Nummulitic formations of Egypt, Tunisia and Algeria have received careful attention. On the other hand, non-French Continental and British publications have been considered in a very uneven manner, but this is excusable in a work of world-wide scope.

F. E. ZEUNER

NEW METHODS OF PREPARING BLOCK COPOLYMERS

By P. E. M. ALLEN, J. M. DOWNER, G. W. HASTINGS, Prof. H. W. MELVILLE, F.R.S., P. MOLYNEUX and J. R. URWIN

Department of Chemistry, University of Birmingham

In recent years increasing attention has been given to the problem of the synthesis of block copolymers; that is, of copolymers in which the long-chain molecule contains long sequences of each type of monomer unit, as opposed to the normal copolymer molecule in which the units are distributed quite randomly. The term 'block' copolymer is not standard. We use it to describe linear molecules, whereas branched structures, arising from the attachment of side-chains of one type of monomer unit on to a backbone of the other type, we call 'graft' copolymers.

During the past few years a number of methods for the preparation of block copolymers have been described[1–9]. In most of these methods the yield of block copolymers is small—sometimes of the order of 10 mgm.—and in many cases separation is complicated by the presence of large quantities of other material of high molecular weight. Another complication in some of these systems arises from the difficulty in distinguishing between block and graft copolymer structures. Of all the processes listed above, only that of Woodward and Smets[5] can safely be said to give high yields of an unequivocable block copolymer which may be separated and obtained in a form uncontaminated by homopolymer or graft and random copolymers.

A number of these methods are purely chemical, involving either the use of a bifunctional initiator such as the phthalyl peroxide used by Woodward and Smets, or the introduction of a labile terminal group on to the growing chain by means of a suitable transfer agent such as bromotrichloromethane[2]. Both these methods lead to a homopolymer of the first monomer *A* containing a labile end-group which may be used to initiate polymerization in a second monomer *B*, or to couple with a suitable terminal group in a polymer of *B*. The great advantage of this method is that the first block may be fractionated before proceeding with the second stage, which greatly simplifies the fractionation of the final product. The method described below in which a dihydroperoxide is used to polymerize styrene is of this type. A polystyrene having a terminal hydroperoxide group is obtained, which is fractionated, and fractions having suitable molecular weight are used to polymerize methyl methacrylate.

Alternatively, the block copolymer may be built up in one stage from a continuously growing radical, the change in character of the chain being effected by transferring the radical end from an environment of monomer *A* to that of monomer *B*. Methods such as that of Hicks and Melville[3], who devised a method by which polymerizing methyl methacrylate or acrylonitrile may be injected into a large excess of styrene, and that of Dunn and Melville[1] in which the growing radical passes through a phase boundary, from, say, styrene in oil phase to acrylic acid in water, may be included in this group. A method is described here which utilizes the trapped radicals remaining in the polymer particles when an emulsion polymerization is taken to completion.

The methods described so far must all lead to block copolymers of the type $A_n.B_m$, or the sandwich-type molecule $A_lB_mA_n$, depending on the relative proportions of the combination and disproportionation radical termination reactions. The third method does not have this limitation. The essence of the method is to rupture the polymer chain by some mechanical method such as mastication[8], ultrasonic irradiation[4,6], or γ-radiation[9]. Such degradation is not accompanied by the depolymerization reaction characteristic of thermal degradation. If two different polymers are degraded together, as described below, a cross-termination of the radicals results in a block copolymer. Alternatively, a polymer *A* may be degraded in the presence of monomer *B* as described by Henglein[4].

The Dihydroperoxide Method

Monomeric styrene was polymerized in bulk using *m* di-(hydroperoxy-*iso*propyl) benzene at 50° C. The polymer formed was freed from initiator by successive precipitations from benzene to methanol. The presence of hydroperoxy groups in the polymer has been demonstrated by the method of Wagner, Smith and Peters[11]. The polymer was then fractionated by a benzene–methanol solvent–precipitant system.

The second stage was carried out in emulsion. The hydroperoxy-ended styrene was dissolved in methyl methacrylate and the solution emulsified with a 'Manoxol O.T.' soap solution. The polymerization was initiated by ferrous ions according to the redox mechanism:

$$R.OOH + Fe^{2+} \rightarrow RO— + OH^- + Fe^{3+}$$

The polymerization was carried out under oxygen-free nitrogen at 0° C. In a typical run the total weight of polymer would increase by about 50 per cent.

A turbidimetric titration of a benzene solution of the polymer against methanol revealed the presence of considerable quantities of polymer intermediate in properties between polystyrene and polymethyl methacrylate. The turbidimetric titration technique is described in more detail below.

A full-scale fractionation was carried out using the benzene–methanol system. Nine fractions were taken, and their polystyrene content determined by examination of the absorption maximum at 2620 A. One fraction of 0·58 gm. was found to be pure polystyrene; three fractions, of total weight 2·28 gm., had a styrene content of 82–89 per cent; two fractions, amounting to 0·22 gm., contained 68 and 69 per cent styrene; and the remainder contained 1·39 gm. of polymer containing 8 per cent styrene. It is suggested that the 82–89 per cent styrene fractions arise from polystyrenes containing one hydroperoxide group, whereas the 68 per cent fraction comes from dihydroperoxy-polystyrenes.

The Emulsion Method

It has been established[11–13] that the site of the reaction in an emulsion polymerization lies in the polymer particles formed in the initial stages. The reaction is maintained by diffusion of monomer and initiator radicals into the particles from the aqueous medium. A large polymer radical cannot diffuse out of its particle into the aqueous phase, so the only way in which it may be terminated is by the diffusion of another initiator radical into the particle. If the generation of initiator radicals is stopped, the polymer radicals unterminated at that stage will remain trapped in the particles even when the polymerization ceases on the exhaustion of monomer. If an emulsion of a suitable second monomer is now added, the new monomer will diffuse to the polymer particles and, in those particles which contain trapped radicals, polymerization will be resumed, yielding block copolymer molecules.

We have used this process to prepare block copolymers of vinyl acetate and methyl methacrylate. Vinyl acetate emulsions stabilized by 'Manoxol O.T.' were irradiated at 20° C. by γ-radiation from a 100-curie cobalt-60 source. The polymerization was followed dilatometrically, and when the process had reached 70 per cent conversion the source was removed. The polymer latex was mixed with a methyl methacrylate emulsion (a manipulative delay of 30 min. usually occurs) and the second stage of the polymerization was followed dilatometrically at 40° C.

The rate of polymerization of vinyl acetate by γ-radiation has been found to be extremely rapid and G values of 10^5 for monomer conversion have been found. In a typical run using a 20 per cent by volume vinyl acetate emulsion and a dose-rate of $6{\cdot}5 \times 10^{16}$ eV./c.c./min., a rate of conversion of 0·11 gm. monomer per min. was observed in a volume of 12·5 ml. This is equivalent to a G value of 94,500 monomer molecules/100 eV.

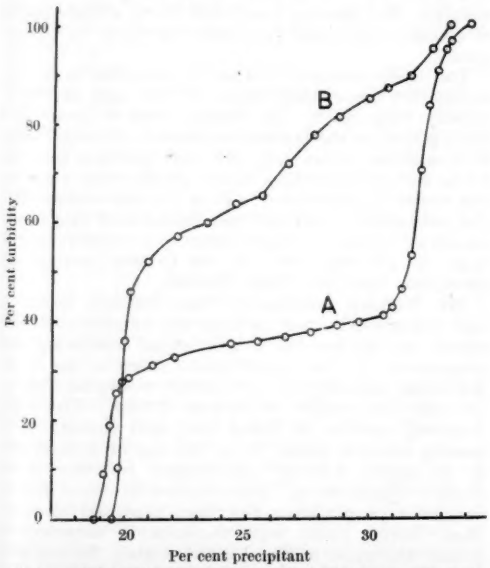

Fig.1. (*A*) Turbidimetric titration of a solution of polyvinyl acetate and polymethyl methacrylate. (*B*) Turbidimetric titration of a solution containing vinyl acetate–methyl methacrylate block copolymer prepared by the emulsion method

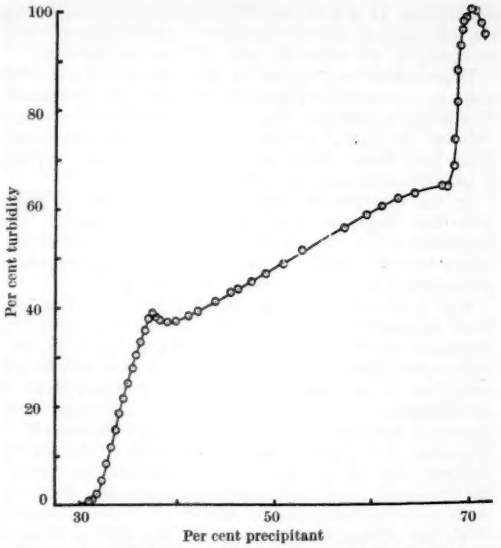

Fig. 2. Turbidimetric titration of a solution of polystyrene and methacrylate after ultrasonic irradiation

The latex formed under such conditions converted a methyl methacrylate emulsion at a rate of about 1 per cent per min.

Turbidimetric titrations were carried out on the polymer produced. This technique has been described elsewhere[14]. It is essentially a titration of a very dilute solution of the polymer (about 5 mgm./100 ml.) against a precipitant, the amount of polymer precipitated at a given point being indicated by the rate of increase in the turbidity of the solution. Curve *A* in Fig. 1 represents a turbidimetric titration of an acetone solution of polyvinyl acetate and polymethyl methacrylate against water. Percentage turbidity, that is, the ratio of optical density to optical density at complete precipitation, is plotted against the percentage of added water. It will be seen that the turbidity increases rapidly between 19 and 22 per cent water and again between 31 and 35 per cent. These steps may be attributed to the precipitation of the polymethyl methacrylate and polyvinyl acetate fractions, respectively.

Curve *B* is a titration of a polymer prepared by the methods described above. A sharp step is again observed between 19·5 and 22 per cent water, so presumably some polymethyl methacrylate is formed, either from hydroxyl radicals trapped in the vinyl acetate latex or from polymerization initiated by heat or a trace of peroxide in the methacrylate emulsion. However, precipitation continues at a steady rate beyond the 22 per cent water point until, in the region of 33 per cent water, the precipitation of large quantities of polyvinyl acetate causes the suspension to coagulate. The titration curve is indicative of a polymer mixture containing large quantities of polyvinyl acetate, a certain amount of polymethyl methacrylate, and a considerable amount of block copolymer varying widely in composition and molecular weight.

Ultrasonic Method

When a polymer solution is irradiated with ultrasonic waves, degradation occurs under cavitating

conditions. It is now established that this occurs with the production of free radicals[14], which are removed presumably by reaction with solvent molecules.

Degradation of polymer in the presence of a second monomer would be expected to result in the formation of a block copolymer, the radicals produced by chain scission initiating polymerization of the monomer. This has been tried successfully for the system polyacrylamide–acrylonitrile[4].

In the method described here, two different polymers are degraded simultaneously in solution, the polymers being chosen so that their radicals combine when they interact. A suitable pair of polymers is polystyrene and polymethyl methacrylate.

Fig. 2 shows the titration of a mixture that had been degraded for 12 hr. This shows a pronounced discontinuity at 37 per cent methanol, and the turbidity increases continuously between this and 68 per cent, at which point polymethyl methacrylate is precipitated. Polystyrene itself is normally precipitated between 31 and 38 per cent methanol. A degraded polystyrene sample is almost completely precipitated at 37 per cent methanol (turbidity, 90 per cent), and polymethyl methacrylate does not begin to precipitate until about 68 per cent methanol. With an undegraded mixture of the two polymers, the curve shows a horizontal portion between the precipitation limits of the two polymers. The central portion of the curve thus represents a third molecular species present in the mixture—in this case a block copolymer formed by cross-termination of the radicals. Its structure would probably be of the 'sandwich' type, since when any copolymer is formed it can undergo further degradation. The copolymer appears to have a wide distribution of molecular weight, but this is expected since ultrasonic degradation is a random process, and radicals produced will have a wide range of sizes. Secondary copolymer degradation will also complicate the picture.

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IODINE AND FLUORINE IN NUTRITION

THE final meeting of a series on "Nutritional Requirements and Food Fortification", arranged by the Nutrition Panel of the Food Group of the Society of Chemical Industry, was held on April 11; the subject was "Iodine and Fluorine". In the first part of the meeting, dealing with iodine, the speakers were Prof. M. M. Murray (Bedford College, University of London) and Mr. J. C. M. Holman (Chilean Iodine Education Bureau); in the second part, on fluorine, the speakers were Prof. Murray, Miss J. R. Forrest (dental officer, Ministry of Health), Dr. G. Wynne Griffith (medical officer of health, Anglesey) and Dr. J. Longwell (Department of the Government Chemist). Copies of the various papers had been circulated in advance and the authors spoke briefly, illustrating the chief points with explanatory slides. The following account includes points raised in the discussion and the replies.

In the first part of the meeting, on iodine, Prof. Murray dealt with the uptake of iodine, the synthesis of thyroid hormones and their state in the circulation. It was pointed out that when the supply of iodine is inadequate, the thyroid in the first place becomes hyperplastic and increases in size, because the low level of circulatory thyroid hormone stimulates the release of thyroid-stimulating hormone from the anterior lobe of the pituitary.

Enlargement of the thyroid gland in adolescents and goitre in adults occurs to a greater or lesser degree in most parts of the world, even at the present time. Where the dietary intake of iodine is abundant, namely, in Iceland and Japan, the thyroid gland is small, rich in iodine and of comparable size in males and females.

It has long been considered that the iodine content of the water supply is a determining factor in the occurrence of endemic goitre. In the United States, surveys showed that areas with waters having 3 μgm./litre iodine were free of endemic goitre; in many places in England and Wales this level is inadequate. Other factors in soil and water play an important part; one of these may be the water hardness, since a significantly greater incidence of thyroid enlargement in children occurs in places where the water is hard as compared with places where the water is soft, but with comparable iodine content. For rats on low iodine diets, a high intake of calcium carbonate has been shown to be goitrogenic.

The daily intake of iodine for man has been put at 100–150 μgm.; only about 10 per cent of this is usually supplied by the water, even in areas free from goitre, so the remainder must be obtained from food sources. Since only fish, fish products and sea foods are rich in iodine, many people must exist on the verge of inadequacy. It is for this reason that the iodization of salt has been introduced into many countries, some by compulsion; it would appear wise to advocate the use of iodized salt in all countries, including Great Britain.

Mr. Holman emphasized that endemic goitre is still widespread; and because this produces adverse effects on the general health, social well-being and educability of the population, there is an overwhelming necessity for preventive measures, that is, to raise the intake of dietary iodine. The most practical method of doing this, and thereby eradicating endemic goitre, is by the use of iodized salt, a procedure actively encouraged by the World Health Organization. The community use of iodized salt as a prophylactic has been practised for more than thirty years, with remarkable decreases in goitre incidence in the United States, Switzerland, New Zealand, Poland and elsewhere. The level of iodization is 1 part of potassium iodide in 10,000–200,000 parts of salt. These levels respectively

supply 500–100 μgm. of iodine per day per person, and even at the higher level no deleterious effects have been found. In Great Britain the level recommended by the Medical Research Council is 1 part in 40,000 of salt.

The iodization of salt is easy and inexpensive and the methods of production were clearly explained. The iodization of 'free-running' vacuum-dried salt, which is extensively used in more developed countries, is also simple. For the crude, coarse salt, produced in under-developed areas, a conveniently simple technique has been devised whereby a controlled mixing of the required weight of potassium iodide or iodate, already mixed with inert powder such as calcium carbonate to give greater bulk, is fed into a bulk mixer.

Potassium iodate has been shown by experimental tests on man to be effectively used by the thyroid gland and has been used for the iodization of salt with good results in certain countries for the past few years. The stability of salt iodized by potassium iodide was considered and data presented to show that loss of iodine is not appreciable from dry and free-running salt, if it is free from impurities and contains a stabilizer, is packed in impervious linings and stored in a dark, cool place for several months. For open pan and solar salts stored in hessian bags, particularly in adverse climatic conditions, potassium iodide is not suitable; the loss is considerable, and therefore potassium iodate should be, and has been, effectively used because of its greater stability. It was not considered necessary to change the methods of iodization now in use in Great Britain.

To those who still have the impression that iodized salt might be unsuitable for certain individuals, the reply is that the amount of iodine in certain sea foods is considerable; and that the use of the high-level iodized salt has not provided any evidence for this belief. Changes in the distribution of endemic goitre take place at all times, the incidence has decreased markedly in some places and increased in others; this is considered to be due to changes in water supplies, dietary habits and population distribution.

Prof. Murray opened the second part of the meeting, on fluorine, emphasizing the following points. Fluorine occurs in bones and teeth, which consist mainly of calcium hydroxyapatite ($3Ca_3(PO_4).Ca(OH)_2$), the fluorine replacing OH groups in the lattice. The proportion of fluorine present increases with age and in proportion to the amount present in the water supply or the diet and when there is exposure to industrial sources of fluorine. So far, it has not been possible to prove that fluorine is an essential dietary element; although it is now generally accepted that the use of water supplies with 1 or more parts per million (p.p.m.) of fluoride is associated with a lower incidence of dental caries than waters with less.

Fluorine can accumulate in bones, and excessive intakes produce osteosclerosis, increased density and exostoses. However, the average daily intake in Britain is about 1 mgm. (water level of 0·2 p.p.m. fluorine) and 2·5 mgm. if the water has 1 p.p.m. fluorine, and this latter quantity is insufficient to cause excessive accumulation. Severe outbreaks of fluorine poisoning in animals have occurred in Britain, due to the eating of pastures contaminated with fluorine dusts from industrial undertakings, and it remains to be proved whether this 'neighbourhood hazard' affects the human population.

A high intake of sodium fluoride in laboratory animals can cause decreased kidney tubular function and inhibition of gastric acid secretion; the amounts used in these tests are outside the range likely to be encountered in endemic fluorosis.

Miss Forrest dealt with the matter of greatest interest, namely, caries incidence and fluoride in the water supply. In the United States a definite inverse relationship has been proved between caries in children and the level of fluoride naturally present in water. The best effects are seen in those born and living up to eight years in a fluoride area, although some protection is seen in children who are newcomers. In 1944 in South Shields (water 1·4 p.p.m. fluorine) the 5–14-year old children had 45 per cent less caries than in North Shields (water free from fluorine). The mechanism by which the fluorine gives this protection is not known; one suggestion is that it is due to the increased proportion of fluorapatite in the enamel. The various degrees of 'mottling', with and without staining, were illustrated by excellent coloured slides. Mottling occurs in 90 per cent of the population where the water has 5–6 p.p.m. fluorine, but at 1 p.p.m. mottling is less frequent and very mild. More recent surveys in areas in the United Kingdom with 5·8, 3·5, 2·0 and 0·9 p.p.m. fluorine, respectively, and fluoride-free areas have confirmed the findings in the United States. In the area with 0·9 p.p.m. there was 60 per cent less caries than in a trace-fluoride area; in the former 30 per cent of the children were free from caries and only 30 per cent had noticeable mottling.

Artificial fluoridation to a level of 1 p.p.m. was started in certain communities in the United States and Canada in 1945; the incidence of caries in children before and after has been compared with control non-fluorine areas. The results show that caries incidence has steadily decreased, and after the ten years by about 60 per cent, in the fluoridation areas, but remained unchanged in the control areas. Fluoridation at 1 p.p.m. is about to be introduced into four areas in the United Kingdom.

Dr. Wynne Griffith described the signs and symptoms of chronic industrial and endemic fluorosis in man, pointing out that radiological changes in the bones are not always associated with disability. Bone lesions and severe disability in a certain proportion of persons have been recorded from areas in India, China and South Africa with waters having more than 4 p.p.m. fluorine; in these places it is likely that malnutrition increases the deleterious effects of fluoride. Dr. Griffith quoted evidence that the normal human kidney can excrete fluoride well in excess of the proposed level of fluoridation; nevertheless, a recent report from an endemic fluorosis area (Hyderabad, Deccan, water 11·8–5·2 p.p.m. fluorine) records impairment of kidney function in a proportion of individuals; but this was not proved to be due specifically to the fluoride.

On the basis of certain general health surveys in natural fluorine and fluoridation areas, Dr. Griffith concluded that available evidence gave no support to the contention that 1 p.p.m. represents any hazard to human health.

Mr. Longwell gave useful figures which he has recently obtained for daily fluoride intakes in Britain. These were: men 3·2 mgm., women 2·2 mgm. and children 1·2 mgm., amounts comparable to those recorded in the United States. He then dealt with

the practical aspects of fluoridation of water, for which either sodium fluoride or sodium fluorsilicate is used. The proportioned addition to the main water supply of a solution of the chemical compound is carefully controlled by special meters. This addition should be made at the final stage of water treatment, when chlorination takes place. Frequent estimations of the fluoride content of the domestic supply must be made and records kept.

Time limited the discussion on fluorine; but in answer to a leading question, Miss Forrest made it quite clear that the fluoride-level in water is an important, but not the only, factor influencing tooth structure and the incidence of caries.

AUTOMOBILE FREE-PISTON ENGINES

By F. D. ROBINSON
Engineering Laboratory, University of Cambridge

NEARLY twenty years have passed since Sir Frank Whittle's first gas turbine ran and six years since the Rover car JET I was driven around the circuit at Silverstone; yet there is still no commercial vehicle driven by gas turbine anywhere in the world other than those few used for experimental purposes. Now, according to a report in *The Times* of April 16, General Motors have developed a free-piston engine for passenger motor-car service. Since the same Company has already produced an automotive gas turbine, it is perhaps a significant comment upon the prospects of gas turbines applied to vehicles that further research has been expended on an alternative prime mover.

It must be obvious to most engineers, in spite of Chryslers' success in the United States, that the gas turbine is at present still an unsuitable engine for the passenger car as visualized in Great Britain, where economy and compact size are of paramount importance. Perhaps one day when blade cooling has been developed, component efficiencies raised, regenerator sealing problems solved and turbine design improved to a level where part-load performance can match full-load performance, then the gas turbine may compete with the petrol and the diesel engine. It is, in fact, arguable if the effort put into producing a suitable small gas turbine would not bring a much greater reward if expended in designing small diesel engines.

Superficially, the new free-piston engine presents many attractive features. It should first perhaps be noted that this type of engine is not at all new. The Junkers version was used to compress air during the Second World War. In the United States a few large gas generator plants of around 1,000 and 1,500 s.h.p. have been built, mostly experimentally, by Baldwin–Lima–Hamilton and by Cooper–Bessemer, and in Britain free-piston air compressors delivering 100 cu. ft. of air per minute have been in use for some years. It is in France, however, where development has been nearly as intensive as that devoted in Britain to gas turbines, that the greatest progress has been made, and SIGMA with their 1,200 s.h.p. gas generator have achieved some notable results. A standard design is available and is in commercial use providing the motive power for mine-sweepers, trawlers, merchant ships, base power generation and pumping sets.

From a thermodynamic point of view, a gas generator is the combination of a diesel two-stroke engine, which fulfils the dual functions of a self-driven compressor and a combustion chamber, with a gas turbine using the high-pressure exhaust gases released from the diesel to produce the useful work. Since the work output of the diesel is expended in compression, it becomes logical to compress by a reciprocating piston attached to the diesel piston and so to omit the usual crankshaft and associated bearings. Various arrangements have been proposed and used; but the travel of the diesel and compressor pistons is always limited only by pneumatic and not by mechanical restrictions. The cycle is the pure constant-pressure cycle; but since the diesel cylinder contains the high-temperature gases and is only intermittently exposed to them, a very much higher peak temperature and compression ratio are possible than when a simple gas turbine is used. On the other hand, the intermittent process in the diesel cylinder makes it impossible for the engine to handle the huge quantities of air associated with a simple turbine. As might be expected when due allowance has been made for the losses which occur in practice, the performance of a free-piston gas generator is a compromise between that of the two engines of which it is compounded. Thus the power–weight ratio is a little better than in conservative diesel practice, but well below gas turbine possibilities, while the fuel consumption is always very much better than gas turbine consumptions. In fact, at full load, economy is nearly equal to that of a diesel, and even at half load compares favourably with that of a petrol engine.

Apart from these inherited merits, the free-piston engine has advantages peculiar to itself and suited to its application to automotive use. Thus vibration is very slight, so mountings can be of a simple nature. It lends itself to considerable flexibility in installation and thus it is quite feasible to place the turbine at a considerable distance from the generator cylinder, substituting a pneumatic drive for a mechanical one. One or more generators may feed the same turbine or presumably vice versa. The torque characteristic is very satisfactory, a large torque being produced at zero turbine speed, while the response to acceleration requirements both from an idling and from a cruising speed are ideal. This cannot be said for the simple gas turbine as, if the compressor and compressor-turbine are idling, the inertia of the combined rotating system is considerable and acceleration from idling conditions is poor unless provided by gearing. With the gas-generator the response is immediate, the only fly-wheel effect being in the power turbine.

On the debit side there are several features, particularly of mechanical design, which suggest that it will be a long time before this form of engine rivals the standard types. Its advocates always emphasize the absence of crankshaft, bearings, poppet valves and cam-shafts in the free piston engine. These are not, in fact, components which give trouble, or, under good conditions of lubrication and filtration, wear at all rapidly. In their place the free-piston engine

imports several complications of its own. Accurate alignment of the four pistons and subsequent lack of distortion are required; non-return valves are freely strewn about the engine, so that leakage due to dirt, oil-varnish and distortion is always a possibility. Although there is no orthodox crankshaft, a light synchronizing mechanism is employed, while a fuel injector and its actuating mechanism are required. The two most sensitive features of the plant are the top ring of the exhaust piston and the gas turbine. It is possible by derating and by conservative design to sacrifice fuel consumption and achieve reliability with these components; but if run at full load, such evidence as is available suggests rapid wear of piston rings due to the compression pressures and temperatures, which are excessive compared with orthodox two-stroke diesels, where piston crown temperatures and ring sticking are always limiting features of design. Of course, it is well known that the working life of a passenger motor-car engine is passed almost entirely at part load, so that conditions are much less severe in this application. Similarly, the gas turbine can use low-temperature exhaust gases and so be made of non-strategic materials if the efficiency of the plant is compromised, or full load is maintained for short periods only. Matching of diesel and turbine over a wide range of speed and load is also known to be difficult.

Claims are made for the omnivorous nature of the free-piston engine. It is true that the free-piston engine will run on a wide variety of fuels—pea-nut oil is quoted—but so will the diesel engine, which has been well tested on palm oil, pea-nut oil, coconut oil, linseed oil and, what is more to the point, residual fuels. The vegetable oils are in point of fact prohibitively expensive, and in any event satisfactory combustion of a fuel is only a first essential; what is equally important is prolonged life of vital parts in face of attacks by products of combustion. This problem has not been solved for high-sulphur fuel oils in diesel engines and certainly not in free-piston engines.

It is praiseworthy that in the face of so many problems General Motors should pursue this line of research, and it is only concerns of such magnitude that can afford to investigate projects with a long chance of success. For, apart from the inherent difficulties of the free-piston gas generator, steady progress in the technical improvement of the diesel, leading to smaller, lighter and cheaper units, and even of the well-tried petrol engine, is still being made. General Motors are sensibly cautious upon the future prospects of the free-piston engine, but it will be interesting to watch the development of this slightly exotic prime mover, and to wonder whether it may be produced in a size one-fifth of the 250 h.p. engine General Motors quote as a respectable minimum.

INFRA-RED SPECTROSCOPY AND CHEMICAL INDUSTRY

By Dr. H. W. THOMPSON, F.R.S.

IT is now generally accepted that much of the recent remarkable progress in the organic chemistry of complex molecules and natural products could not have been achieved without the help of the numerous modern physico-chemical techniques. Most of these new tools have a clearly defined sphere of utility. For example, chromatography is applied almost exclusively in the separation of mixtures or for purification of compounds, and isotopic tracers are for the most part used in the elucidation of reaction mechanisms. Infra-red absorption spectroscopy, on the other hand, can be applied in a wider sense. Its value in industry is twofold: first for qualitative or quantitative analysis, and secondly for the determination or clarification of molecular structure. In both these respects the range of applicability is enormous, and much of the information gained in the course of the work can be of great value in other connexions. The structural studies can be made with molecules in all states of aggregation, and the method is now pointing to a new line of attack on the nature of intermolecular forces and intermolecular complexes.

Many discussions on these applications of infra-red spectroscopy have been held during the past fifteen years, and they have served to illustrate the continual progress in many directions. Nevertheless, the symposium organized on April 9–10 by the London Section of the Society of Chemical Industry was opportune, for it provided an opportunity to take stock of the present position, not only as regards the experimental facilities now available but also in regard to the theoretical basis and possible extension of the different lines of application. The large attendance, and the diversity of problems which were raised, showed that the scope of this particular technique is still widening. It is now being used, in penetrating fashion, in the chemistry of fuels, textiles, paints, dairying, perfumes, polymers and resins, pharmaceuticals and antibiotics, and other general chemicals.

Industrial work requires two kinds of infra-red equipment, namely, (i) spectrometers with the appropriate accessories for use in research laboratories, and (ii) other apparatus for use on the plant in process control. The most urgent need in Britain at present is in the latter respect. Prism spectrometers of rugged stability are now commercially available for the region 1–40μ to meet all normal requirements. Although costs are still high, a choice can be made according to the spectral range to be studied, the resolving power required, and the speed and method of recording. Some general flexibility is also desirable so that accessories can be attached, such as long-path absorption cells, a reflecting microscope, or a low-temperature absorption cell. In view of the limited spectral range of the known photoconductive cells, it might be helpful if fast and more sensitive, spectrally black, bolometers could be developed. Also, although a satisfactory variety of synthetic crystalline materials for prisms and windows is now available, something might be gained from further examination of such substances as lead chloride. The resolving power provided by good commercial prism spectrometers is now adequate for most purposes, but the recent success in making cheap replica diffraction gratings has opened up the possibility of simple grating spectrometers. It is possible, in fact, that for more satisfactory work on band intensities, the higher resolving power may become necessary; but if such grating instruments are to be developed, more systematic work on filters should be undertaken.

The position as regards availability of instruments for flow-line control is less satisfactory, and this is where much help can be given to industrial production. For many years it has been clear that certain components of common industrial gas streams could be monitored continuously by means of their infra-red absorption. For such work, either dispersive or non-dispersive analysers can be used, measuring either the integrated infra-red absorption over a wide spectral range, or some selected band which has been isolated by means of filters or by a simple dispersing system. Typical components measured in this way include carbon monoxide and dioxide, sulphur dioxide, hydrogen sulphide, ammonia, acetylene, ethylene and other hydrocarbon gases. Much progress has been made in the United States and also in Germany with such instruments, in some cases leading to an effectively automatic process control. The older non-dispersive analysers use either a black-body detector with filters (negative type), or microphone detectors which are selectively sensitized to a particular spectral region (positive type). Improvements in both stability and sensitivity have been achieved by a combination of both types in the Perkin–Elmer 'tri-non' analyser. With all such equipment, the details of design must be carefully considered with specific reference to the gas stream involved, since in all cases the ease of determination of the main component is affected by the absorption of other substances present. Also, for plant operation, the most vital factor is obviously long-term reliability; but the difficulties in this respect have been overcome, and concentrations varying between parts per million and 90 per cent can be measured convincingly. An alternative method, using the so-called 'bichromator', is to use a simple prism spectrometer with split Littrow mirror, so that the absorption at two different wave-lengths can be compared continuously, one wave-length acting as a reference standard. For some purposes, this type of instrument has advantages over the non-dispersive analysers. The main conclusion is that there are scope and need for such plant control instruments in British industry. A few are already in use, and it is understood that others are to be installed for the analysis of water – heavy water mixtures.

Conventional infra-red analysis using prism spectrometers is being used on an ever-increasing scale. Among new examples are the determination of plasticizers, oil and rubber additives, copolymers, residual water in fibres, antibiotics, resins and paints. The pressed-disk technique has facilitated work with insoluble materials, although the quantitative background of this method needs further examination. Hitherto, most analyses have used the region 1–14μ, but the merits of other spectral regions are now becoming evident. Between 1μ and 3μ, where vibrational overtones are involved, more conveniently measurable thicker layers can be used, and several problems involving polymers, including the determination of end groups, have been solved.

Qualitative and semi-quantitative analysis has advanced significantly by use of 'differential spectroscopy'. If the absorption of the main component in a mixture is overlaid or masked by the absorption of other components, the background absorption of the latter may be cancelled out by use of a double-beam spectrometer in which a compensating cell is placed in the 'blank' beam. This method demands proper experimental care, but is capable of giving spectacular results. It has been applied successfully to many problems in the fuel industry and suggests a new approach to the discrimination between closely similar complex materials such as proteins, carbohydrates and polymer products. Meanwhile, the theoretical basis of infra-red quantitative analysis is now being examined critically. The optical densities at band peaks, which lead to the 'apparent' extinction coefficients, cannot really be regarded as satisfactory measures of band intensities, for they are much affected by the relatively wide spectrometer slits which are used in infra-red work, and by other instrumental factors. Unfortunately, therefore, quantitative data from different laboratories often disagree, and this has so far made it impossible to establish intensity values of universal applicability. The shapes and 'apparent' extinction coefficients of many vibrational bands have now been determined as a function of slit-width, and the experimental requirements for obtaining satisfactory 'reproducible' values of peak densities have been examined. At the same time, band intensities have been measured by taking the integrated absorption over the whole band. This latter method seems to provide a measure which is far less dependent upon spectrometer characteristics, and automatic integrating devices have therefore been developed. Whether it will prove better, as a regular procedure, for general analytical work, to use higher resolving power and the peak extinction coefficients, or to measure the integrated band areas, remains still undecided, but it should soon be possible to assess the relative merits of the two methods.

The use of key absorption bands for structural diagnosis has also reached an interesting stage. It is based upon the localization of certain molecular vibrations within a small group of linked atoms, and ceases to be of much value if nuclei of comparable mass are joined together by single valency bonds so that a larger part of the whole molecule is concerned in the vibration. A few more correlation rules may still be discovered, and there are suggestions that some characteristic differentiation of stereoisomers may be possible. However, the bulk of the useful data is now available, and more attention is being given to disentangling the influences within a molecule which cause the general rules to break down. The exact nature of the hydrogen bond is again under consideration, and interesting 'inter-space' group interactions have been found. It may, however, now be profitable to explore the use of intrinsic band intensities for diagnostic work. Results show that different types of a particular group can be distinguished in this way, and the comparison of the intensities of fundamental and overtone bands may sometimes be even more informative.

Among the ancillary techniques used for studying complex molecules, polarized infra-red radiation has been applied to ordered structures and crystalline materials, and the spectral changes arising from deuteration are sometimes instructive. The reflecting microscope has greatly simplified work on fibres such as silk or 'Terylene'. The α (helical folded) and β (open chain) forms of polypeptides have been distinguished, and natural and synthetic peptide materials have been compared. These methods have also been applied to the general problem of the crystallinity of polymers, which is so much related to their physical properties. In pharmaceutical chemistry, infra-red spectra are being used as a means of proving identity, for quantitative assay, and for unravelling the structure of steroids, hormones and antibiotics.

One new line of great significance is the study of inter-molecular interactions through the displacements of vibration bands. This may lead to valuable information about adsorption processes, adhesion, and the formation of intermolecular complexes in reacting systems.

Many of these more elaborate contributions to research problems are of real interest; but it is important not to lose sight of the more mundane and urgent needs of analytical process control mentioned above. There are hopeful signs that the necessary instruments may soon become available.

OBITUARIES

Prof. Megh Nad Saha, F.R.S.

THE death on February 16 from sudden heart failure, at the age of sixty-two, of Prof. M. N. Saha has robbed India of one more of her leading men of science. He was well known for his distinguished researches, for his activity in scientific administration and for his other public activities. After an early education in India he came to England for post-graduate studies under Prof. Alfred Fowler at the Imperial College of Science and Technology, London. It was there that he developed his work on thermal ionization, which led up to 'Saha's equation', by which he will be remembered. By taking account of the important effect of pressure, as well as of temperature, in a gaseous mixture of neutral atoms, ions and electrons, he explained the increase in ionization as one moves outwards from the photosphere to the chromosphere of the Sun. His work led to important developments by R. H. Fowler and E. A. Milne in the study of the pressures and temperatures of stellar atmospheres. It has earned a permanent place in the history of astrophysics.

On going back to India, Saha returned to physics, and as professor of physics successively at the Universities of Allahabad and Calcutta he founded research schools on ionospheric problems and nuclear physics. He published many papers on a wide range of subjects, including the propagation of electromagnetic waves in the ionosphere, the escape of radio waves from the Sun, nuclear physics and spectroscopy. His position in the world of Indian science may be gathered from the many leading positions that he held from time to time. He was president of the Indian Science Congress, of the United Provinces Academy of Science (later the National Academy of Sciences), and of the Indian Association for the Cultivation of Science and the National Institute of Sciences. He was largely instrumental in founding the Institute of Nuclear Physics, Calcutta; as its director he was active both in training students and in supervising research work.

He was a member of the Board (or later Council) of Scientific and Industrial Research, which led to growing interest in the social relations of science, a subject on which he wrote a number of papers. As he grew older and became an established figure in his own country, he turned more and more to questions of education, industrialization, national planning and such details as river valley projects. [His last paper of this kind appears on p. 923 of this issue of *Nature*.] In 1951 he was elected to the Indian Parliament by a large majority as an independent member, having refused to stand as a party candidate. He loved fighting for causes which he felt to be right, even though by so doing he earned unpopularity in Government circles. But he retained a keen, active interest in science, and only last year was one of the Indian members attending the General Assembly of the International Astronomical Union in Dublin. His sixtieth birthday was celebrated by a volume on his life, work and philosophy arranged by a committee of the Indian Association for the Cultivation of Science (see *Nature*, 174, 528; 1954). It is sad that he should have survived its publication for so short a time.

F. J. M. STRATTON

Mr. T. Harold Reade

THOMAS HAROLD READE, the third son of the late Thomas Reade, manufacturing chemist, of Wolverhampton, was born in 1889. He was educated at St. Paul's School, London, where he was a contemporary of Lord Montgomery, and at the University of Birmingham, where he graduated in science. During the First World War, Reade served in France and in Palestine, first with the 6th South Staffordshire Regiment and later with the Machine Gun Corps. On demobilization he went to Emmanuel College, Cambridge, where, under Dr. Hamilton McCombie, he carried out research on the preparation and properties of phenyltrimethylammonium perhaloids, perfecting methods for the determination of the constitution of these compounds. In 1921, Reade graduated and was appointed to the staff of the University of Aberdeen, where he became responsible for the teaching of organic chemistry, a duty which he performed with thoroughness and distinction until his retirement in 1945. A man of strong personality, a trifle impetuous, he was an inspiring teacher and a pleasant colleague.

Throughout his period on the University staff, Reade maintained an active research programme. Following on his work at Cambridge, he studied the addition compounds of halogens and quaternary ammonium salts, showing experimentally that the iodine in these perhalides is reducible but not oxidizable to molecular iodine and therefore is in a higher state of oxidation. Later, in collaboration with his research students, he investigated, among other problems, the simultaneous nitration of the nucleus and nitrosation of the nitrogen atom in a considerable number of dialkyl anilines by means of sodium nitrite in hydrochloric and sulphuric acids, finding a method of controlling the type of reaction that predominated. The numerous contributions which he made in these various spheres are recorded in the *Journal of the Chemical Society*.

In his retirement Reade devoted his leisure to golf and music; he was an accomplished performer on both the golf course, where on many occasions he represented the staff of the University of Aberdeen in inter-university competitions, and on the piano. His sudden death, on March 24, came as a great shock to his many friends; taken ill while playing his usual game of golf at his club, the Royal Aberdeen, he died a few hours later in hospital. He was unmarried.

R. B. STRATHDEE

NEWS and VIEWS

New Foreign Members of the Royal Society :

Prof. K. U. Linderstrøm-Lang

Prof. K. U. Linderstrøm-Lang, director of the Carlsberg Laboratory, Copenhagen, whose election as a foreign member of the Royal Society has recently been announced, is famous for his researches on proteins and for his pioneer work in the field of enzyme histochemistry. As a young man, his reputation was established by his acetone-titration method of estimating amino-acids ; he followed this with a series of investigations on the physical chemistry of proteins, dealing *inter alia* with protein denaturation and various aspects of protein degradation by enzymes. His Lane Medical Lectures of 1952 on "Proteins and Enzymes" and his contribution to the Solvay discussion on proteins the following year show the breadth of his interests and his ability to apply theoretical treatment to his problems. One of the most interesting of his recent contributions has been the discovery and unravelling of the transformation of ovalbumin to plakalbumin. An investigator possessed of great manipulative skill, he has invented many ingenious methods of microanalysis which have enabled him to throw light for the first time on chemical reactions going on in individual cells. As an illustration, one may cite his elegant demonstration of the mechanism whereby the larvæ of the clothes moth are able to digest wool. Under his inspiring leadership the Carlsberg Laboratory has fully maintained the fine international reputation which had been handed down by his predecessor, S. P. L. Sørensen.

Prof. Hans Pettersson

With his election to the foreign membership of the Royal Society of London, Prof. Hans Pettersson, the well-known Swedish oceanographer, joins six eminent compatriots already in that distinguished company. Born in August 1888, son of Prof. Otto Pettersson, the renowned oceanographer who founded the International Council for the Exploration of the Sea and who died fifteen years ago at the age of ninety-three, Prof. Hans Pettersson has added greatly to the lustre of a family name so closely associated with marine research. After studying physics in Upsala under Knut Angström during 1908–11, he entered upon that period of work in England under Sir William Ramsay which gave him his love of London and his remarkable command of English. In 1914 he became both a doctor of physics of the University of Stockholm and a research associate in oceanography at Gothenburg. Eight years later he was leading a team of workers in the Radium Institute of Vienna in radioactivity and nuclear physics, and it is due to his skill in those fields that he has made such fruitful researches on the radium content of deep-sea sediments and on the rate of their accumulation. The author of numerous papers on oceanographical topics, he became professor of the subject at Gothenburg in 1930 and director of the Oceanographical Institute there in 1939. He is a member of learned societies of many countries and holder of the Patron's Medal of the Royal Geographical Society of London. Pettersson organized and led the highly successful Swedish Deep-Sea Expedition with the *Albatross* during 1947–48.

Dr. Fritz Zernike

The election of Dr. F. Zernike as a foreign member of the Royal Society is the latest honour he has received in recognition of his distinguished work in physical optics, and in particular for his researches in phase-contrast microscopy. His election follows on the award in 1952 of the Society's Rumford Medal and in 1953 of the Nobel Prize for Physics. Zernike first described the principle of the phase-contrast method in 1933 in a short paper to the twenty-fourth Dutch Physical and Medical Congress ; but prior to that his published papers were mainly concerned with the statistical aspects of a variety of physical problems. By extending Abbe's theory of the microscope, he showed both theoretically and experimentally, using apparatus which he had himself constructed, that an image of a phase-grating consisting of transparent lines alternating in thickness could be made visible if the phase of the direct image of the source were changed by 90° relative to the diffracted light. The elaboration of this principle is now well known and forms the basis of the highly successful phase-contrast microscope. Zernike has also carried out important fundamental work on the diffraction theory of optical images, including the effect of small amounts of aberration and of the coherence of the illumination. After being dormant for a period, the subject of microscopy has come very much to life during the past decade, and it is fair to attribute much of this vitality to the stimulus of Zernike's ideas.

Paris Academy of Sciences : Elections

The following elections have been made in the Paris Academy of Sciences : Prof. P. Tardi, professor of astronomy in the École Polytechnique, Paris, to be a member of the Geography and Navigation Sections in succession to the late Prof. E. de Martonne ; Prof. A. Vandel, professor of zoology in the University of Toulouse, to be a non-resident member of the Academy in succession to the late Prof. M. Gignoux ; Prof. H. Lundegårdh, professor of plant physiology in the Agricultural College, Upsala, to be a *correspondant* for the Rural Economy Section in succession to Prof. S. Waksman, recently elected a foreign associate of the Academy ; Prof. E. Schmidt, professor of mathematics in the Humboldt University, East Berlin, to be a *correspondant* for the Geometry Section in succession to Prof. S. Bernstein, recently elected a foreign associate of the Academy ; Prof. C. Killian, professor of agricultural and experimental botany in the University of Algiers, and Prof. F. W. Went, professor of plant physiology in the California Institute of Technology, to be *correspondants* for the Botany Section in succession to the late Prof. G. Nicolas and the late Prof. P. Becquerel.

Leverhulme Research Awards, 1956

The Leverhulme Trustees have approved the following fellowships and research grants, among others, tenable for periods up to two years, the subject of study being indicated in brackets : *Fellowships :* R. A. Crowson, lecturer in zoological taxonomy, University of Glasgow (young stages and habits of certain primitive endemic Coleoptera in New Zealand) ; Dr. P. J. C. Dark, Department of Anthropology, University College, London (Mixtec ethnohistory : an analysis of the codical art) ; Dr. A. T. A. Learmonth, lecturer in geography, University of Liverpool (land use in the Assam Valley with special reference to population density and capacity) ;

Dr. A. I. Richards, formerly director, East African Institute of Social Research, Makerere College, Uganda (changes in the political system of the Bemba of North Eastern Rhodesia, 1935–55); Dr. E. G. Richardson, reader in physics, University of Durham (propagation of sound in a turbulent medium); R. A. Skelton, superintendent of Map Room, British Museum (foundation and early history of the Ordnance Survey, 1782–1825). *Research Grants:* Dr. R. F. Barrow, Fellow of Exeter College, Oxford (spectroscopy of simple molecules); A. R. Bailey, Turner and Newall Research Fellow, Imperial College, London (intercrystalline cracking and failure of high-tensile brass); P. R. Bell, lecturer in botany, University College, London (phylogeny and morphology of the ferns of tropical mountains); Prof. F. Debenham, emeritus professor of geography, University of Cambridge (the Admiralty and the Arctic in the nineteenth century); Lady Drower (a dictionary of the Mandaic language); Dr. K. A. Kermack, lecturer in biological statistics, University College, London (American mesozoic mammals); A. D. Rees, director of extra-mural studies, University College, Aberystwyth (an examination of some of the more important branches of Celtic mythology); H. Thomas, assistant buildings officer, University of Manchester (application of architectural acoustics to the design and construction of schools for the deaf); Prof. D. Williams, professor of Welsh history, University College, Aberystwyth (Benjamin Franklin's circle in London). Further information about the awards can be obtained from the Secretary, Leverhulme Research Awards, St. Bridget's House, Bridewell Place, London, E.C.4.

Royal Aeronautical Society

HONORARY fellowship of the Royal Aeronautical Society has been conferred on Sir Roy Dobson and Dr. Hugh L. Dryden. The following awards have been made by the Society: *British Gold Medal for Aeronautics*, to the late Mr. Joseph Smith for his outstanding practical achievements in the design and development of military aircraft; *British Silver Medal for Aeronautics*, to Mr. J. Fenwick for his contributions to the development of air-traffic control systems; *The Society's Gold Medal*, to Sir William Farren for his outstanding contributions to aeronautical research and development (this is the Society's highest honour for work in aeronautics); *The Society's Silver Medal*, to Dr. E. S. Moult for his outstanding contributions to aeronautical engineering and, in particular, for his work in the design of aircraft engines; *The Society's Bronze Medal*, to Mr. J. W. Barnes for his contributions in the field of aircraft instruments; *Wakefield Gold Medal*, to Group Captain W. K. Stewart for his contributions to the design and development of aero-medical equipment; *George Taylor (Australia) Gold Medal*, to Mr. R. H. Woodall for his paper on some trends in the development of aircraft electrical and starting systems; *Simms Gold Medal*, to Mr. K. V. Diprose for his paper on analogue computing in aeronautics; *R. P. Alston Memorial Prize*, to Mr. D. P. Davies for his practical achievement in the flight testing of prototype civil aircraft; *Edward Busk Memorial Prize*, to Mr. L. E. Fraenkel for his paper on the unsteady motion of a slender body through a compressible fluid; *Herbert Akroyd Stuart Memorial Prize*, to Mr. O. N. Lawrence for his paper on fuel systems for gas-turbine engines; *Usborne Memorial Prize*, to Dr. G. N. Lance for his paper on the lift of twisted and cambered wings in supersonic flow; *Orville Wright Prize*, to Mr. K. W. Gunn for his paper on the effect of yielding on the fatigue properties of test pieces containing stress concentrations; *Branch Prize*, to Mr. W. Tye for his paper on the outlook on airframe fatigue (second Barnwell Memorial Lecture); *Royal Aeronautical Society Navigation Prize*, to Mr. John Grierson for his paper on the evolution of Arctic airways; *Pilcher Memorial Prize*, to Mr. H. Caplan for his paper on the investigation of aircraft accidents and incidents.

Iron and Steel Institute

THE following awards have been made by the Iron and Steel Institute: *Bessemer Gold Medal for* 1956, to Dr. C. Sykes (Thos. Firth and John Brown, Ltd.) in recognition of his distinguished contribution to the study of alloy systems, particularly in the field of order–disorder changes and the effect of such changes on the physical properties of alloys; *Sir Robert Hadfield Medal for* 1956, to Mr. H. Morrogh (British Cast Iron Research Association) in recognition of his distinguished contribution to the study of the metallography of cast iron and for researches which resulted in the discovery of nodular iron and the improvement in the quality of cast iron; *Additional Williams Prize for* 1954, jointly to Mr. F. A. Gray and to Mr. S. A. Brooks (Appleby–Frodingham Steel Co., Ltd.) for their paper on an investigation of re-heating furnace design and performance; *Williams Prizes for* 1955, to Mr. A. J. Kesterton (Steel Company of Wales, Ltd.) for his paper on some starting and operating experiences at Abbey melting shop, and to Mr. R. Wilcock (Samuel Fox and Co., Ltd.), for his paper on the operation of a 60-ton arc furnace at Samuel Fox and Co., Ltd.; *Ablett Prizes for* 1955, to Mr. W. Ernest (Samuel Fox and Co., Ltd.) for his paper on waste heat recovery related to the generation of electric power; to Mr. S. R. Phelps (Guest Keen and Nettlefolds, Ltd.) for his paper on electrical requirements of flying shears for bars and billets; and to Mr. R. Stewartson (Guest Keen and Nettlefolds, Ltd.) for his paper on the mechanical design features of flying shears for bars and billets.

Royal Australian Chemical Institute

THE following awards have been made by the Royal Australian Chemical Institute: *H. G. Smith Memorial Medal*, 1955, to Prof. R. S. Nyholm, professor of chemistry, University College, London, for his work in inorganic chemistry; *Rennie Memorial Medal*, to Dr. D. R. Stranks, assistant lecturer in radiochemistry, University of Leeds (this Medal is awarded to an Australian chemist less than thirty-one years of age for papers published during the past ten years); *Masson Memorial Scholarship*, 1956, to G. C. Morris, of the University of Sydney, now studying for his M.Sc.

Nuclear Power

THE first number of the new journal by Rowse-Muir Publications, Ltd., *Nuclear Power* (1, 1; May 1956; single copy 3*s*. 6*d*., annual subscription £2 2*s*.), has now been published. This journal, designed to "further the development of atomic energy and nuclear techniques for peaceful purposes and in particular to credit British achievements", has an editorial panel of distinguished scientists from British universities and from the U.K. Atomic Energy Authority. Subjects covered in this first number include the methods and plants used for the

production of heavy water, dose-rate meters, the production of reactor fuel elements, and the research facilities at the research laboratories of Tube Investments, Ltd., and at the Battelle Institute, Columbus, Ohio. There is also the first of a series of articles on reactor physics by J. F. Hill, of the Reactor School, Harwell. Other sections of the journal consist of editorial comments, news items from various parts of the world, news of equipment used in connexion with nuclear engineering, and abstracts of patents. The remaining section is devoted to reviews of books of use or of interest to the nuclear engineer. Synopses of the articles are given in five languages. These, as well as the contents on the title page, are in type which is unusually small in size. It is stated that forthcoming issues will contain papers, articles and features on nuclear fuel enrichment, fabrication and reprocessing, on reactor design, construction and performance, on the associated power plant, on instrumentation and on isotope production, handling and application to industry.

Courses and Awards in Technology

Details of the award to be given by the recently created National Council for Technological Awards, under the chairmanship of Lord Hives, have been announced. The National Council will grant a diploma in technology, the courses for which will be equivalent in standard to honours degree courses of a British university. The award will be denoted by 'Dip. Tech. (Eng.)' for engineering and by 'Dip. Tech.' for other technologies. There will be two honours classes and a pass level. The courses which will be recognized may be either full-time or sandwich. The minimum time required for a course in a technical college will be three years full-time or four years sandwich course. Students attending full-time courses will be expected to have suitable industrial training amounting in aggregate to not less than one year in industry. The minimum age of admission to courses will normally be eighteen. It should be assumed that the standard of admission to courses will be that of the General Certificate of Education, with two appropriate subjects at advanced level and three subjects at ordinary level, or a comparable standard. Holders of good Ordinary National Certificates, for example, will be eligible; in most other cases National Certificate holders will need additional instruction to qualify for entry to the course. Since the courses are intended for those aiming at becoming professional technologists, they should include a thorough education in the fundamentals of science and technology and their application to development and design. To help fit the students for future responsibilities, the courses must include liberal studies and some instruction in the principles of industrial organization.

Colleges seeking recognition for a course must make formal application to the Council. They will be expected to provide a substantial programme of advanced studies. In particular, the subjects constituting the course must be conducted in an environment where advanced studies are the main preoccupation of the staff. Good library facilities and social amenities are necessary. It is desirable for the college to have residential facilities; but the absence of such facilities will not prevent courses from being recognized at the moment. It is intended, however, to make this a condition as soon as possible. The staff will be expected to be of high quality. In particular, the leaders of each branch of study should have either higher degrees and substantial academic experience, or suitable academic qualifications supported by substantial industrial experience or both. They should also be professionally active in their subjects. It is highly desirable that colleges and industry should arrange their conditions of employment so that interchange of staff for suitable full-time periods can be encouraged. In assessing the staff, the emphasis will be on their intellectual and personal qualities. They should include persons to whom industry would go for advice. Above all, they will be expected to be good teachers and to be able to relate their industrial experience to their teaching work. It is essential that staff engaged on the course should have opportunities for research. Details of the procedure for applying for the recognition of suitable courses and the fees to be charged for the courses will be announced later.

Permanent Commission of the International Fisheries Convention

The fifth meeting of the Permanent Commission set up under the International Fisheries Convention of 1946 took place in London during May 8–11. Delegations attended from all thirteen of the member governments, namely, Belgium, Denmark, the Federal German Republic, France, Iceland, Ireland, the Netherlands, Norway, Poland, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland. Observers were present from the Union of Socialist Soviet Republics, which was represented for the first time. There were also observers from the International Council for the Exploration of the Sea, the Food and Agriculture Organization of the United Nations, and the International Commission for the Northwest Atlantic Fisheries. Much of the Commission's discussion was devoted to the report of an *ad hoc* scientific committee set up at the previous meeting to review available information and to advise the Commission on minimum mesh sizes and minimum size-limits for fish, and to say whether any changes were required. This report is to be published, and it was agreed to recommend that the member governments should have it translated and should seek the views of their own fishing industries, and should report back with their recommendations and proposals by December 31, 1956. Meanwhile, the 75-mm. minimum mesh for ordinary trawls will be continued until April 4, 1958. The Commission also gave further attention to the problem of mixed fishing for protected and for other species. The Commission appointed a Committee composed of representatives of the six countries most concerned, namely, Belgium, France, the Netherlands, the Federal German Republic, Poland and Sweden, to study this problem further for the next meeting. Finally, the Commission received reports from the International Council for the Exploration of the Sea on the question of a definition of the light trawl, and the problem presented by the capture of undersized whiting in the industrial fisheries. No further action is to be taken at present on these problems since the International Council is continuing its investigations. Klaus Sunnanaa (Norway) was elected president for the next three years in succession to R. G. R. Wall (United Kingdom), whose term of office had expired, and A. Alloy (France) was elected vice-president in succession to Dr. G. Rollefsen (Norway). The Commission will hold its next meeting in London beginning on May 14, 1957.

K. W. Feuerbach and his Geometrical Research

One of the most important theorems of the geometry of the triangle that was developed during the nineteenth century is the one which shows that the nine-point circle of a triangle is tangent to the inscribed and to each of the three escribed circles of the triangle. The theorem was discovered and first proved by Karl Wilhelm Feuerbach, a little-known mathematician who led a short and tempestuous life; an account of his life and researches has been given by Prof. Laura Guggenbuhl (*Scientific Monthly*, 81, No. 2; 1955). Feuerbach's proof was purely algebraic, being modelled upon the proof in an article by Euler in 1765; but while it is in principle simple enough, the detail of the working is exceedingly laborious, and in succeeding years many people, fascinated by the difficulties in Feuerbach's proof, seemed to find it a pleasant challenge to produce a different and simpler one. Feuerbach, the third son of a family of eleven, was born in Jena in 1800, his father being a successful lawyer. Shortly after the publication of his book, Feuerbach, only twenty-two years old and without previous teaching experience, was appointed professor of mathematics at the Gymnasium at Erlangen. Soon afterwards, he studied for a time at the University of Freiburg under Karl Buzengeiger, who is credited with having had a great influence upon the young mathematician. On returning to Erlangen, however, he was involved in political troubles and was arrested. At his trial he was acquitted; but he spent more than a year in prison awaiting trial, and during this time he commenced some further mathematical research. This was later completed, and was the subject of a review by Cantor in the *Sitzungsberichte der Heidelberg Akademie der Wissenschaften*; in a final summary, Cantor says that Feuerbach in this work proved himself to be an independent co-discoverer with Mobius of the theory of the homogeneous co-ordinates of a point in space. At the time of his imprisonment, Feuerbach was already showing signs of mental derangement, and by 1828 this was so serious that he had to retire from teaching. He died six years later when not yet thirty-four.

Mycological Collections in Latin America

The attention of mycologists is directed to the Second General Catalogue of Latin American Mycological Collections, published under the auspices of the Unesco Centre for Scientific Co-operation (Centro de Cooperación Cientifica para América Latina de la U.N.E.S.C.O., Bulevar Artegas 1320, Casilla de Correos 859, Montevideo, Uruguay; 1955). Indications are given of all the fungi in the collection and of the institutions or laboratories where they are maintained. Full information on the origin, biological properties and characteristics of the cultures, biographical citations, etc., can be obtained on application to the Centro de Cooperación.

The United States National Museum

The annual report of the United States National Museum for 1955 records the opening of the First Ladies Hall on May 24, 1955. The eight display units in the Hall are designed to represent different rooms in the White House, Washington, from the earliest period to the present time and contain architectural details acquired from the House during its recent reconstruction. They give the public an opportunity to view the dresses in surroundings similar to those in which they were originally worn. Each room contains three to six dresses representing a time of about twenty years. The changing styles in White House decoration shown in these rooms are based on available drawings and photographs together with written descriptions.

Royal Society Depository of Unpublished Mathematical Tables

The following is a list of accessions to the Royal Society's depository of unpublished mathematical tables since the publication of the last list in *Nature* (175, 712; 1955): (52) Étude de $3n^3 + 1$, $3n^4 + 1$, $3n^5 + 1$ (A. Ferrier); (53) Table of $\mathrm{Bi}'(+x)$, for $x = 0(0{\cdot}01)2$ and $\mathrm{Bi}'(-x)$, for $x = 0(0{\cdot}01)10$ (K. I. McKenzie and M. Rothman); (54) Table of a function related to the error function (H. J. Gawlik); (55) Étude de $5n^3-1$, $5n^4-1$ (A. Ferrier); (56) The self-consistent field for Zr^{4+}: supplementary tables (S. L. Altmann); (57) Tables for the regular reflexion of plane shocks in air (C. K. Thornhill and Katharine M. Stocks); (58) Tables of quantities associated with oblique shocks in air for which the flow deflexion is a maximum or behind which the flow is sonic (C. K. Thornhill and Katharine M. Stocks); (59) Tables of Sievert's integral (S. Johnston); (60) Solutions of the Poisson–Boltzmann equation for two equal spherical colloidal particles (N. E. Hoskin); (61) Tables of Fresnel integrals (J. R. Airey). Further information about these tables can be obtained from the Assistant Secretary, Royal Society, Burlington House, London, W.1.

International Union of Forest Research Organizations: Congress at Oxford

The twelfth Congress of the International Union of Forest Research Organizations is to be held in Oxford during July 7–14 and will be followed by organized tours in various parts of Britain. It is expected that nearly two hundred delegates from twenty-five countries, mainly European but including Canada, Australia, New Zealand, the United States and Japan, will take part. The previous Congress was held in Italy in 1953. The Union was founded as long ago as 1890, and its aims include the establishment of close personal relations between forest research workers of all countries, particularly between specialists working in the same field of activity. The meetings at Oxford will be under the following main headings: general forest influences; forest production; establishment and maintenance of forests; forest economics—operational efficiency; and forest products. The Congress is to be opened at Regent's Park College, Oxford, on July 7, by the Minister of Agriculture, Mr. Heathcoat Amory, and during the week-end there will be local tours for delegates. In the ensuing week, meetings of the Congress will be held at the Imperial Forestry Institute and there will be a closing plenary session on July 14 in Regent's Park College. On July 12 excursions will be available to the Forestry Commission's Research Station at Alice Holt Lodge, near Farnham, Surrey; the Forest Products Research Laboratory at Princes Risborough; and the Rothamsted Experimental Station, Harpenden. Following the Congress, there will be seven separate tours—three in England, three in Scotland and one in Wales—and the programme will include visits to Forestry Commission areas and a number of private estates known for their outstanding forestry.

Announcements

Prof. Arthur Holmes, regius professor of geology in the University of Edinburgh, has been awarded the Penrose Medal for 1956 of the Geological Society of America. The Medal is awarded, on occasion, in recognition of outstanding original contributions or achievements which mark a decided advance in the science of geology.

Sir Harry Jephcott has been appointed chairman of the Advisory Council of the Department of Scientific and Industrial Research in succession to Sir Hugh Beaver, who has resigned; Sir Hugh will continue to serve as a member of the Council.

Dr. R. A. Wilkins, vice-president, research and development, of the Revere Copper and Brass, Inc., Rome, New York State, has been elected a Fellow of the Institute of Metals in recognition of his outstanding services to the Institute, and in particular as corresponding member to the Council in the United States. Fellowship of the Institute is limited to twelve, and Dr. Wilkins is the first member resident outside the British Isles to be elected.

The official title of the Commonwealth Bureau of Dairy Science at Shinfield, Reading, has been changed to the Commonwealth Bureau of Dairy Science and Technology. It is felt that this will reflect more accurately the scope of the Bureau's activities.

A summer laboratory course on techniques and applications of the electron microscope will be held during June 11–23 in the Department of Engineering Physics of Cornell University. The course will be on the lines of those held in previous years. Further information can be obtained from Prof. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, N.Y.

A summer school in programme design for automatic digital computing machines will be held in the University Mathematical Laboratory, Cambridge, during September 17–28. The course will be along the same lines as those held in previous years. Application forms, to be returned by June 15, and further information can be obtained from the secretary of the Board of Extra-Mural Studies, G. F. Hickson, Stuart House, Cambridge.

The annual course on tropical hygiene for laymen will be held by the Ross Institute this year during July 16–20. The course is intended for those whose work in the tropics makes them responsible for the health and welfare of others. There is no fee. Further information can be obtained from the organizing secretary, L. G. Ponsford, Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine, Keppel Street (Gower Street), London, W.C.1.

The sixth summer school on welding, organized by the British Welding Research Association, will be held at Ashorne Hill, near Leamington Spa, Warwickshire, during June 18–23. After a general introduction, the course will be divided into four separate groups dealing with the following topics: gas-shielded welding; resistance welding; metallurgy and physics of welding; and inspection, testing and quality control in welding processes. Application forms and further information can be obtained from the Organizing Secretary, Sixth Summer School of Welding, B.W.R.A., 29 Park Crescent, London, W.1.

A Joint Committee of the Field Studies Council and the Royal Meteorological Society is again arranging a short vacation course in meteorology, which will be held at Malham Tarn Field Centre, near Settle, Yorks, during August 22–29. The course will be directed by Mr. C. D. Ovey, University lecturer in geography, Cambridge, and Dr. R. S. Scorer, University lecturer in meteorology, Imperial College of Science and Technology, London. The main emphasis will be on practical aspects of meteorology. The inclusive fee for the course is £7. Particulars can be obtained from the Publicity Secretary, Field Studies Council, Ravensmead, Keston, Kent.

Applications are invited by the Atomic Energy Research Establishment, Harwell, from physicists and electronic engineers holding a degree or equivalent qualification, who wish to attend the eleventh specialized course, during June 11–15, on the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry, and in work with radioisotopes. Attendance at the course is limited to twelve; the syllabus will include lectures and practical work concerned with counters, d.c. and pulse amplifiers, coincidence units, scalers and ratemeters, and the lecturers and demonstrators will be specialists from the Atomic Energy Research Establishment. The subject will be entirely non-secret. The fee for the course is 15 guineas, and living accommodation can be arranged locally at a charge of four guineas approximately. Application forms can be obtained from the D.A.O., Electronics Division, A.E.R.E., Harwell, Didcot, Berkshire. These must be returned by May 25.

The Sixth International Mechanical Engineering Congress will be held in Paris during June 4–9, the subject for discussion being "Surface Treatment for the Improvement of Mechanical Properties and Protection against Corrosion". The following topics will be considered: improvement of resistance to wear by increase of surface hardness; improvement of resistance to wear through improvement of friction characteristics; improvement of resistance to heat; improvement of resistance to corrosion by metal coatings deposited by means other than electroplating; improvement of resistance to corrosion by electroplating processes; improvement of resistance to corrosion by chemical processes; improvement of resistance to corrosion by non-metallic coatings; and surface treatment for decoration and for improving optical properties. The official languages of the meeting will be English, French and German. Further information can be obtained from the Permanent Secretariat of the 6th I.M.E.C., 11 avenue Hoche, Paris 8e.

The second annual Guenter Loeser Memorial Lecture of the Geophysics Research Directorate of the Air Force Cambridge Research Center will be given this year by Dr. Robert G. Breene, jun., speaking on the "Phenomenological Considerations of the Interruption Theory of Line Broadening". The lecture will be delivered on June 29 in the Charter Room of the New England Mutual Building, Boston, Mass.

The Central Laboratories for Scientific and Industrial Research, Hyderabad, have been formally taken over by the Council of Scientific and Industrial Research, Government of India, and will henceforth be known as the Regional Research Laboratory, Hyderabad. This is the first regional laboratory of the Council. Dr. S. Husain Zaheer remains as director, and the research staff will continue as before.

FUEL IN INDIA

By the late Prof. M. N. SAHA, F.R.S.

THE relative contributions of different types of fuels to the total energy production in India has received attention from many quarters in recent years[1–4]. Unfortunately the statements made are often contradictory; in this article I shall try to clear up this confusion.

By 'fuel' I mean anything which gives energy on combustion: coal, oil, wood, cattle dung, dried twigs and leaves. Other energy-producing agencies are nuclear fuel, which has not yet been used in India, and hydroelectricity. To compare the relative contributions of the different types of fuels to the total fuel economy of India, we have to know the absolute calorific value of each type of fuel.

The absolute calorific value of a fuel is the amount of heat given off on its complete combustion. This is listed for various types of fuels in Table I[5].

Table 1

Fuel	Calorific value (k.cal./lb.)
Soft coke	2,550
Hard coke	2,850
Charcoal	3,500
Wood (dry)	2,000
Dry leaves	1,500–2,000
Cow-dung (sun-dry)	1,500
Petroleum products (average)	4,460

Coal. The coal production in India in 1952 was 35 million tons. This was distributed among the consumers as follows[3]:

Table 2

Consumer	Amount consumed	Percentage
Railways	11·5 million tons	32·8
Iron and steel	4·0 " "	11·4
Collieries	2·0 " "	5·7
Steam and electric utilities	2·5 " "	7·15
Brick, cement, potteries, refractories and lime kilns	3·0 " "	8·6
Mills, works, etc.	3·0 " "	8·6
Bunker and export	3·5 " "	10·0
Other industries	2·5 " "	7·15
Domestic	3·0 " "	8·6

From Table 2, it can be seen that less than 10 per cent of coal in India is used as domestic fuel, so that more than 90 per cent of coal burnt is used by industries.

Petroleum products. The total amount of petroleum products imported into India in 1952 was 3·3 million tons, while the indigenous production was only 0·22 million tons; so the total was 3·5 million tons, which has a calorific value of 35×10^{12} k.cal. (see ref. 3). From Table 1, it can be seen that the equivalent amount of coal giving the same energy as the petroleum products in India per annum would be about 6 million tons.

Hydroelectricity. Total output of hydroelectric power in India was about 2,000 million kWh.[3], which is equal to $1{\cdot}72 \times 10^{12}$ k.cal. Assuming 30 per cent efficiency for the conversion of heat energy into electrical energy in a modern thermal station, the above amount of electrical energy should be equivalent to the burning of about 1 million tons of coal.

Cattle dung. Cattle dung is an important domestic fuel in India, though there is a good deal of controversy about its relative contribution to the fuel economy of the country. We can estimate the total amount of energy derived by burning cattle dung in the following manner. The cattle population (which includes cows as well as buffaloes), according to the Report on the Marketing of Cattle in India (1946)[6], was 212 million in undivided India. Taking the cattle population to be three-fourths of this number after partition, India should have now about 160 million. This is in agreement with the figure of 177·4 million published in the Draft Outline of the First Five Year Plan, published by the Planning Commission (1951)[7].

According to the Report on the Marketing of Cattle in India[6], the average Indian cow (adult) produces about 25 lb. of green dung a day, whereas the young cow produces about 18 lb. a day. The contributions of the adult and young buffaloes are 60 lb. and 40 lb. a day respectively, as given in the above report.

The actual fuel value of cow-dung can then be calculated from the data given above. Assume that of the 180 million head of cattle, 140 million are cows and 40 million are buffaloes, and that the percentages of adult and young among cows and buffaloes are 70 per cent and 30 per cent. Then the amount of dung produced by 140 million cows is approximately $100 \times 25 + 40 \times 18 = 3{,}220$ million lb. per day. Similarly, the amount of dung produced by 40 million buffaloes is approximately $30 \times 60 + 10 \times 40 = 2{,}200$ million lb. per day. Hence, the total amount of dung produced is $\frac{3{,}220 + 2{,}200}{2{,}240} =$ 2·42 million tons per day, say 890 million tons a year.

Now according to the Memorandum on the Development of Agriculture and Animal Husbandry in India (1944)[8] published by the Advisory Board of the Imperial Council of Agricultural Research, only 40 per cent of the total green dung is used as fuel, 40 per cent is used as manure and the remainder is lost. Actually there is some difference of opinion on the percentage of dung used as fuel. Thus the Report of the Expert Committee on Manures and Fertilizers (1953)[9] published by the Ministry of Food and Agriculture, Government of India, gives 50 per cent, whereas according to W. Burns, an officer on special duty in the Department of Education, Health and Lands of the Government of India (1944)[10], this figure should be 66·6 per cent. Here I accept the figure 40 per cent as more reliable. Hence total green dung used as fuel is $890 \times 0{\cdot}4 = 356$ million tons. Again, according to the above Memorandum (1944), 1 lb. of dried cow-dung comes from about 5 lb. of green cow-dung. So the equivalent weight of dried dung is $\frac{356}{5} = 71$ million tons.

Now, if the whole combustible material in dried cow-dung is fully burnt, about 1,500 k.cal. of heat per lb. of dried cow-dung is obtained[5]. But the calorific value of 1 lb. of coal is much higher, being

in the range of 2,550–2,850 k.cal./lb. for Indian coal. The average may be taken to be about 2,700 k.cal./lb. Hence for complete combustion 1 lb. of coal gives as much heat as 1·8 lb. of dried cow-dung. Thus the contribution of cow-dung fuel to the fuel economy of India is equivalent to 40 million tons of coal.

Fuel wood. The position with respect to fuel wood is not very clear. Recorded figures of fuel wood consumption from lands classified as forests indicate an extremely low value, being only about 53 lb. per head per year. According to the President of the Forest Research Institute and Colleges, India, this is a ridiculously low figure (private communication). However, there are reasons for believing that unauthorized wood-cutting amounts to many times the recorded figures, and that leaves and twigs are also utilized as fuel[3]. Actually, some idea regarding the amount of domestic fuel wood burnt annually in India may be obtained in the following manner.

According to Lahiri and Das Gupta[3], the average per capita energy consumption in India amounts to about 80–100 therms per year, which is equivalent to about $2,800 \times 10^{12}$ to $3,500 \times 10^{12}$ B.T.U. a year for the entire population. Of this, about $1,100 \times 10^{12}$ B.T.U. a year is met from coal, oil and hydroelectricity. The remainder must therefore come from wood fuel and farm waste. The energy obtained from these sources must therefore be in the range of $1,700 \times 10^{12}$ to $2,400 \times 10^{12}$ B.T.U. We may therefore assume that about $2,000 \times 10^{12}$ B.T.U. or 500×10^{12} k.cal. of energy are obtained in India per annum by burning wood fuel and farm waste[3,5]. Taking the heating value of 40 million tons coal-equivalent of cattle dung to be about 242×10^{12} k.cal., the heating value of fuel wood should be about 258×10^{12} k.cal., that is, equivalent to 43 million tons of coal approximately. This would bring the per capita consumption of fuel wood in India to about 370 lb. per head per year, which is about seven times the figure quoted above.

Table 3

Fuel	Coal equivalent in million tons consumed annually	Percentage contribution to the fuel economy of India
Coal	35	28·0
Oil and hydroelectricity	7	5·6
Cattle dung	40	32·0
Wood, dried leaves and twigs	43	34·4

We are now in a position to estimate the percentage contribution of different types of fuels to the fuel economy of India. This is shown in Table 3.

[1] Putnam, P. C., "Energy in the Future" (London: Macmillan, 1954).
[2] Lahiri, A., and Das Gupta, A. K., "Problems of Energy Development in India"—I, *Fuel Res. Inst. News*, **4**, No. 3 (1954).
[3] Lahiri, A., and Das Gupta, A. K., "Problems of Energy Development in India"—II, *Fuel Res. Inst. News*, **4**, No. 4 (1954).
[4] Bhabha, H. J., "The Role of Atomic Power in India and Its Immediate Possibilities", International Conference on the Peaceful Uses of Atomic Energy (1955).
[5] Lahiri, A., "Domestic Fuel", *Fuel Res. Inst. News*, **3**, No. 3 (1953).
[6] Agricultural Marketing Advisor to the Government of India. Report on the Marketing of Cattle in India, 66 (1946).
[7] Planning Commission, "The First Five Year Plan—A Draft Outline", 109 (1951).
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THE U.S. NATIONAL ACADEMY OF SCIENCES

ANNUAL MEETING

THE ninety-third annual meeting of the National Academy of Sciences was held in Washington, D.C., during April 23–25. At the annual dinner on April 24, there were two guests of honour: Dr. Alexander von Muralt, past president of the International Council of Scientific Unions, and now president of the National Research Council of Switzerland and rector of the University of Berne; and Dr. John E. Burchard, dean of the School of Humanities and Social Studies at the Massachusetts Institute of Technology, and president of the American Academy of Arts and Sciences. Thirty-four papers were read at five sessions, and, in addition, three other sessions were devoted to symposia on the following subjects: solar and terrestrial relationships; biomolecular organization and life processes; and science in education.

At the meeting the following awards of the Academy were presented: *Agassiz Medal*, to Prof. Alfred C. Redfield, associate director of the Woods Hole Oceanographic Institution; *Henry Draper Medal*, to Prof. Hendrik C. van de Hulst, professor of theoretical astronomy in the University of Leyden; *Elliot Medal*, to Prof. Archie Carr, professor of biological sciences in the University of Florida; *Kimber Genetics Award*, to Prof. Sewall Wright, professor of genetics in the University of Wisconsin; *Kovalenko Medal*, to Dr. Peyton Rous, member of the Rockefeller Institute for Medical Research; *Thompson Medal*, to Prof. Alfred S. Romer, Alexander Agassiz professor of zoology and director of the Museum of Comparative Zoology, Harvard University; *Watson Medal*, to Dr. Chester B. Watts, director of the Six-Inch Transit Circle Division, United States Naval Observatory.

The Agassiz Medal of the Academy, which is awarded for distinguished work in oceanography, goes to Dr. Redfield in recognition of his many and diverse contributions in this field. He has been associated with the Woods Hole Oceanographic Institution since 1931 and has been professor of physiology in Harvard University since the same date. His knowledge of physiology, a field in which he made important contributions before turning to the study of the sea, coupled with his interest in sailing and the seashore, has been an important part of his work in oceanography. For example, he translated the physiological functions of blood into the metabolism of the marine environment in which water and organisms interact as an entity with a physiology of its own. His analyses of biochemical cycles in the sea, of the origin and distribution of organisms, and of the products of biological activity have led to interpretations of the oceanic circulation which incorporate the physical, chemical and biological cycles. Lately he has been studying the development and growth of salt marshes and the genesis and propagation of waves associated with hurricanes.

The Draper Medal, which was established to recognize significant contributions to astronomical physics, has been awarded to Prof. van de Hulst for his noteworthy contributions to the field of radio astronomy and in particular for his prediction, made in 1944, that radiation of 21 cm. wave-length should be emitted by neutral hydrogen in interstellar space.

The probability of the transition in a given atom is extremely low; but because the total quantity of hydrogen in the vast reaches of interstellar space is enormous, detectable amounts of the radiation are emitted. In 1951 observers in the United States, Australia and the Netherlands detected the radiation independently as a sharp line in the radio-frequency spectrum. Because of its sharpness, the line is useful for the determination of the velocities at which the clouds of hydrogen are moving towards us or away from us, and because radiation at this frequency penetrates regions relatively opaque to visible light, the observations have contributed much to the great new fund of knowledge that comes from the rapidly growing field of radio astronomy. Soon after his prediction was confirmed by observation, Prof. van de Hulst, in collaboration with Jan Oort and C. A. Muller, began to study the hydrogen radiation around the equator of our galaxy, and by 1953 they had produced evidence of the spiral structure of the galaxy in striking agreement with observations by other means.

The award of the Daniel Giraud Elliot Medal has been made to Dr. Carr in recognition of his book, "Handbook of Turtles: the Turtles of the United States, Canada, and Baja California" (Comstock Publishing Associates, Cornell University Press, 1952). Dr. Carr has devoted a number of years in the field and the laboratory to the study of the anatomy and zoology of the turtle, and his "Handbook" is an account of all kinds of turtles found in the area north of Mexico, but including Lower California. After discussing the probable evolution of the turtle group with a summary of physiology, adaptation, anatomy and economic value, he describes the various kinds of turtles and their distribution, their appearance being illustrated by many excellent photographs and drawings. The Elliot Medal has been awarded by the Academy annually since 1917, under a provision of the will of Daniel Giraud Elliot expressing his wish to provide a medal and honorarium to the author of any paper, essay or other published work of outstanding merit in zoology or palæontology.

Prof. Wright, the recipient of the Kimber Genetics Award, has made important contributions to both theoretical and experimental genetics. His early experimental work was concerned with the effects of inbreeding in animals, and this led to studies on the relative importance of heredity and environment as causes of variation. His later work has dealt with the problems of physiological and developmental genetics, and, using guinea pigs, he has analysed the complex and remarkable interaction effects of genes. In theoretical genetics, Prof. Wright is perhaps best known for his series of mathematical papers on various aspects of evolution. His theoretical work on the statistical consequences of Mendelian heredity, although directed primarily to the problem of evolution, has had profound effects on the methods by which domestic plants and animals are genetically improved.

The award of the Kovalenko Medal to Dr. Rous is in recognition of his distinguished contributions in the field of experimental medicine. Very early in his career he observed an association between viruses and tumour growth. Because he was so far in advance of his field, working at a time when knowledge of viruses was meagre and cancer research was in its infancy, the significance of this relationship was not at first recognized. For the past two decades he has been actively concerned with the viral etiology of tumours. He has also worked on the physiology and pathology of the liver and the physiology of the blood vessels. In addition, he has been editor of the *Journal of Experimental Medicine* for many years. The Kovalenko Medal was established in 1949 by Dr. M. S. Kovalenko in memory of his wife, Jessie Stevenson Kovalenko, for outstanding contributions to medical science, and Dr. Rous is the second recipient.

Prof. Romer, the recipient of the Thompson Medal, has spent most of his research career studying the comparative anatomy and evolution of vertebrate animals. His speciality has been the reptilian and amphibian life of the Permian period, some 200–225 million years ago, soon after the vertebrates in the course of their evolution had emerged from the water and as their conquest of the land was getting well under way. In this connexion he has shown that the ancestral freshwater fishes already had lungs and other pre-adaptations for land life, and has developed the theory that legs, capable of walking on land, were originally an adaptation for staying in the water. They permitted the ancestral fishes to wriggle from a drying pool across land to other pools still holding water in seasons of drought. Especially noteworthy are his intricate studies of details of the brain-case and reconstruction of vanished nerves in fishes, amphibians and reptiles long extinct. Prof. Romer has himself discovered and collected many of the rare fossil animals that he has studied; he has led many fossil-hunting expeditions, especially in Texas.

Dr. Watts, who receives the James Craig Watson Medal in recognition of his outstanding contributions to astronomical research, has spent the greater part of his forty-five years at the United States Naval Observatory, determining positions of the Sun, Moon, planets and stars; and since 1934 he has been chiefly responsible for the six-inch transit circle, and with a judicious combination of mechanical, optical, photographic and electronic techniques, he has brought the instrument to an extremely high state of perfection. He has recently designed and supervised the construction of a new nine-inch transit circle at the Observatory. The precision of all these measurements is based on observations of the edge of the Moon's disk, and the edge is always irregular because of the high mountains and low valleys on the Moon's surface and also because a slightly different aspect of the edge is seen from time to time. About eleven years ago, Dr. Watts undertook to survey that part of the Moon's surface (comprising some 18 per cent) which is seen as an edge. To survey a surface a quarter of a million miles away to an accuracy of fifty feet required some thousand photographs, the invention and construction of an automatic photoelectric machine for tracing the profile of each photograph and drawing it on a strip of paper 30 ft. long, the design and construction of analogue computers for analysing the profiles and translating them into numerical form, the devising of means for integrating the profiles into a representation of the surface of the Moon in the vicinity of the edge, and finally the development of the most readily usable form for publication of the results. The survey is now complete and will be published shortly.

The following new elections were made to the Council of the Academy: *Treasurer*, Dr. William J. Robbins, director of the New York Botanical Garden, New York (this being the second such term of office

for which he has been elected treasurer); *Members of Council*, Prof. I. I. Rabi, professor of physics, Columbia University, New York, and Dr. F. E. Terman, dean of the School of Engineering, Stanford University, Stanford, Calif. The other officers of the Academy, who were elected in previous years and will continue until expiry of their terms of office, are as follows: *President*, Dr. Detlev W. Bronk; *Vice-President*, Dr. George W. Corner; *Home Secretary*, Dr. Hugh L. Dryden; *Foreign Secretary*, Prof. John Gamble Kirkwood; *Members of Council*, Prof. Farrington Daniels, Dr. E. A. Doisy, Dr. James Gilluly, Dr. Theophilus S. Painter, Dr. Merle A. Tuve and Prof. Edwin B. Wilson.

The following have been elected members of the Academy: G. von Békésy, senior research Fellow in psychophysics, Harvard University; M. Benedict, professor of nuclear engineering, Massachusetts Institute of Technology; K. E. Bloch, professor of chemistry, Harvard University; K. S. Cole, director of the Laboratory of Biophysics, National Institute of Neurology, Diseases, and Blindness, National Institutes of Health, Bethesda; B. L. Crawford, jun., professor of physical chemistry, University of Minnesota; W. A. Fowler, professor of physics, California Institute of Technology; C. P. Haskins, president of the Carnegie Institution of Washington; E. W. Haury, professor of anthropology, University of Arizona; P. Kusch, professor of physics, Columbia University; A. L. Lehninger, professor of physiological chemistry, School of Medicine, Johns Hopkins University; M. G. Mayer, senior physicist, Argonne National Laboratory, Lemont; C. P. Miller, professor of medicine, University of Chicago; W. W. Morgan, professor of astronomy, Yerkes Observatory, University of Chicago; W. H. Munk, professor of geophysics, Scripps Institution of Oceanography, La Jolla; M. S. Newman, professor of chemistry, Ohio State University; R. F. Pitts, professor of physiology, Cornell University College of Medicine; J. D. Roberts, professor of organic chemistry, California Institute of Technology; K. P. Schmidt, emeritus curator, Department of Zoology, Chicago Natural History Museum; M. Schwarzschild, professor of astronomy, Princeton University; C. E. Shannon, research mathematician, Bell Telephone Laboratories, Inc.; F. K. Skoog, professor of botany, University of Wisconsin; N. E. Steenrod, professor of mathematics, Princeton University; W. H. Stockmayer, professor of physical chemistry, Massachusetts Institute of Technology; A. Szent-Györgyi, director of research, Institute for Muscle Research, Inc., Marine Biological Laboratory, Woods Hole, Mass.; C. H. Townes, professor of physics, Columbia University; F. J. Turner, professor of geology, University of California, Berkeley; J. Verhoogen, professor of geology, University of California, Berkeley; M. B. Visscher, professor of physiology, University of Minnesota; J. C. Warner, president of the Carnegie Institute of Technology, Pittsburgh; W. H. Zinn, director of the Argonne National Laboratory, Lemont.

The following have been elected foreign associates of the Academy: Prof. F. G. Gregory, director of the Research Institute of Plant Physiology and professor of plant physiology, Imperial College of Science and Technology, London; Sir K. S. Krishnan, director of the National Physical Laboratory, New Delhi; Prof. A. E. Michotte, professor of psychology, University of Louvain; and Prof. J. J. C. Pérès, dean of the Faculty of Sciences and professor of rational mechanics, University of Paris.

FORESTRY COMMISSION

REPORT FOR 1954

THE annual report of the Forestry Commission for 1954* opens with a statement on the unveiling of a memorial on the site in Keilder Forest where the ashes were scattered of the late Lord Robinson, chairman of the Forestry Commission during 1932–52 and a member of the Commission from its inception.

The year 1954 marks the peak of the Commission's planting so far, a total of 70,400 acres having been achieved, or 2,800 acres more than the previous year. Since the end of the Second World War the rate of annual planting has been increased each year up to this major total. The regular increase, it is noted, has only been maintained by materially reducing the reserves of land awaiting planting. So the point has been reached when the annual planting programme will not only not increase but will in fact fall. The report states that the planting to be carried out in 1955 will bring the planted forest area under the Commission up to and beyond the million acres mark: a truly remarkable and meritorious performance, with all the difficulties and setbacks the Commission has had to face since its inception in 1920, when five million acres of forests were aimed at. More land is required; but the problem is not merely one of acquiring land, for it must be suitably distributed plantable land. There are still large tracts of country running into many hundreds of thousands of acres the best use of which is undoubtedly forestry. It is this type of land which the Commission wishes to acquire if the owners are unable to plant it themselves. Private planting continues to rise steadily though surely: including areas planted without grants, a total of 19,100 acres were planted—nearly a thousand acres more than the previous year.

The production and consumption of home timber were the same as during 1953. The cut in hardwood species was probably less, due to the poorer quality of the timber now being felled and to the abolition of softwood consumer licences in November 1953. It is interesting to note that the expensive home-grown programme inaugurated in 1919 is now beginning to show a financial return, in the pulp and pitwood markets, though difficulties with reference to mining timber and its testing for quality are still under debate. The big Scottish windblow of January 1953 has continued to provide large amounts of timber, of which the National Coal Board has taken advantage. The large intake of home pit-props by the English collieries has been due to an increase in normal production—a most satisfactory position in view of the fact that at the beginning of the century, and before and after, the mines were dependent on Scandinavian and other imports at great cost. Nevertheless, only about one-quarter of the estimated consumption of Britain as a whole is being supplied from home sources.

An interesting investigation is in the possible utilization of inferior and poorly grown hardwoods for wood pulp. The main bulk of these hardwoods are to be found in the south of England, and two British paper-making groups are considering the question of ground wood-pulp for newsprint and

* Forestry Commission. Thirty-fifth Annual Report of the Forestry Commission for the Year ended September 30th, 1954. Pp. 88. (London: H.M.S.O., 1955.) 3s. 6d. net.

"Kraft" pulp for wrapping and packaging. It is said that the requirements of the raw materials for such processes are less exacting in quality and quantity than in the case of dissolving pulp, which is largely used in the manufacture of artificial fibre.

Progress continued in the dedication of woodlands, and during the year the area dedicated increased from 225,000 acres to 343,000 acres.

E. P. STEBBING

AUSTRALIAN ATOMIC ENERGY COMMISSION

A REPORT of the work of the Australian Atomic Energy Commission since its establishment in 1953 is outlined in an article by Prof. J. F. Baxter, vice-chancellor of the New South Wales University of Technology, in the *Australian Journal of Science* (17, No. 5, 151; 1955). Details are given of the initial stages which led up to the establishment of the Commission, its composition and its two main fields of activity, namely, that related to the discovery and production of uranium and that related to the development of the use of atomic energy for industrial and other purposes. In surveying what the Commission has accomplished since its establishment, Prof. Baxter mentions the completion of the plant for the mining of uranium ore at Rum Jungle, which was set in motion by the Prime Minister on September 17, 1954, and of the opening of the Radium Hill mine and concentrator during 1954. A modern treatment plant at Port Pirie was expected to be completed in the near future.

In regard to its responsibilities for the development of uses for atomic energy, the Commission decided to try to obtain access to the large amount of secret information accumulated by Great Britain, the United States and Canada, and to work in partnership with these powers. After various discussions and visits by prominent scientific workers both from Great Britain to Australia and vice versa, Britain offered to give to Australia its accumulated knowledge arising from its industrial atomic-energy programme and, in addition, agreed to enter into a co-operative research programme with Australia whereby the Australian Atomic Energy Commission would set up a research and development organization in Australia while Britain would provide facilities for the training of Australian scientists and engineers in the various British atomic-energy establishments. Accordingly, a Scientific Advisory Committee, consisting of Prof. M. Oliphant, Prof. L. H. Martin, Dr. F. W. G. White, Prof. R. Myers, Prof. T. G. Hunter, Prof. J. S. Anderson, Mr. V. Brain and Prof. J. P. Baxter (chairman), was appointed by the Commission, and a comprehensive group of laboratories has been constructed and equipped on a site some twenty miles south of Sydney.

A large research reactor of a modern type, designed to give a high neutron flux, is to be installed; and a scientific staff of fifty senior scientists and about three hundred other personnel are to be recruited. The chief of research and development is Prof. C. N. Watson-Munro; the chief engineer and deputy chief of research, Prof. G. C. J. Dalton; and Dr. G. L. Miles and Mr. K. F. Alder, leaders of the chemistry and metallurgy departments, respectively. In addition, the initiation and support, on a very large scale, of research and development work in the Australian universities is planned by the Commission, and special facilities for research and advanced training for engineers and scientists from universities and industry in its laboratories at Sydney are to be provided. Finally, a Business Advisory Group has been formed by the Minister for Supply in order that the Commission and leaders of industry may confer closely and regularly on atomic energy matters.

THE TUBER-BEARING SPECIES OF *SOLANUM*

MUCH has been written of the potato, its South American origin, its introduction into Europe, its many varietal forms and its taxonomy. J. G. Hawkes (*Proc. Linn. Soc.*, **166**, 1 and 2, 97; 1956) has now contributed a comprehensive and critical taxonomic study of the tuber-bearing species of *Solanum*, special attention being paid to *S. tuberosum* and the tetraploid species complex. In the designation of a nomenclatural type for *S. tuberosum* the early descriptions of C. Bauhin, Clusius and others are mentioned in relation to those of Linnaeus. Evidence is brought forward to show that one of the three specimens in the Linnean Herbarium labelled as *S. tuberosum* may be considered as the lectotype. It is then pointed out that Linnaeus's description, made when one species of tuberiferous *Solanum* alone was known, could equally well be taken as referring to some 80 per cent of the wild species described later. A new description has therefore been drawn up with attempts to include the complete range of variability of *S. tuberosum* under modern concepts, and this is followed by reference to the main features that distinguish it from other potato species.

The views of the Russian taxonomists on the subdivision of the cultivated tetraploid potato into two distinct species are outlined. The criticisms levelled at these views show that it is impossible to separate the cultivated tetraploids into more than one species and that the weed tetraploids previously described as distinct should also be included within *S. tuberosum*. Experimental data support these views.

An analysis of the difference between the Andean and Chilean South American potatoes makes it possible to recognize two subspecies, namely, (*a*) subspecies *andigena* from the mountains of Venezuela, Colombia, Ecuador, Peru, Bolivia and north Argentina; (*b*) subspecies *tuberosum* from Europe and South Chile. That the European and Chilean potatoes are included under the same subspecific name does not imply that the former were derived from the latter; but that each evolved under similar environmental conditions from original Andean stocks.

As to the origin of the tetraploid potato, it can be considered as an autotetraploid, but may have been formed as an amphidiploid hybrid between two species the genomes of which were not quite identical.

The conclusion is that *S. tuberosum* was derived from an already cultivated diploid species and not directly from a wild one. Indeed, it seems probable that the cultivated potato *S. stenotomum* or a precursor of this species was the original diploid ancestor of our tetraploid potato. There is also evidence that the weed diploid *S. sparsipilum* may also have played some part in the formation of *S. tuberosum*, though cytological opinion is more strongly in favour of *S. stenotomum*.

STRUCTURE OF TOBACCO MOSAIC VIRUS

Radial Density Distribution in the Tobacco Mosaic Virus Particle

MEASUREMENTS of the equatorial scattering of X-rays by orientated gels of tobacco mosaic virus[1] have been used for calculating the mean electron density in the virus as a function of distance from the axis of the rod-shaped particle. Using a Geiger-counter diffractometer with monochromatic copper $K\alpha$ radiation, accurate, high-resolution recordings of the equatorial scattering have been obtained for values of $2\sin\theta/\lambda$ up to 0·06, and for $2\sin\theta/\lambda$ between 0·06 and 0·094 intensities have been estimated from photographs.

Over the angular range examined, the amplitudes of the intensity maxima are real since, for a helix such as tobacco mosaic virus[2], this part of the pattern is determined only by the cylindrically averaged density[3]. Sign relations between some of the maxima can be established from their regular periodicity in certain regions. Where this periodicity corresponds to a dimension about that of the particle diameter, it follows that the amplitude changes sign at the zeros separating the maxima[4]. Radial density distributions were calculated for the sign combinations consistent with these sign relations, and all but two sets were found to be improbable since they would require an unreasonably large diameter for the particle and unlikely density values. Unambiguous determination of the correct set of signs was made from the changes in the equatorial X-ray scattering produced by lead bound to the virus.

When tobacco mosaic virus is treated with lead acetate, lead is specifically bound, and the virus (in concentrated solution) remains soluble with up to about one lead atom added per 17,000 molecular weight of virus. The differences in X-ray scattering from orientated gels of normal and lead-substituted tobacco mosaic virus were used to calculate the radii at which the lead is fixed and to establish the signs of the amplitudes. Equal amounts of lead are found to bind at radii of 25 A. and 84 A.

Using the signs so determined, the Fourier–Bessel transform of the equatorial amplitudes has been calculated to give the radial density distribution in the virus particle. This is shown in Fig. 1.

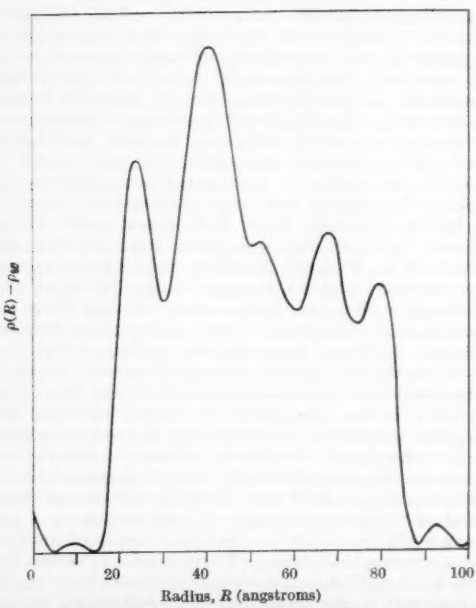

Fig. 1. Radial electron-density distribution in the tobacco mosaic virus particle plotted as a function of distance from the axis of the particle. Ordinate values are proportional to the mean density in excess of that of water

The following features of this transform should be noted: (1) The tobacco mosaic virus particle is hollow. A hole of radius about 19 A. extends along the axis of the particle. (2) The effective radius of the virus in solution is about 84 A., which is appreciably greater than the value 75 A.[1] obtained from the inter-particle distance in dry paracrystals. This difference is consistent with the results of Franklin and Klug[5], who found that there are rather deep indentations in the virus surface which follow the pitch of the helix in such a way that the particles can intermesh in the dry paracrystals. (3) There is a region of high density at a radius of 24 A. and one of higher density at 40 A. The peaks of smaller density at about 67 A. and 79 A. are also significant, but the other minor peaks are diffraction effects from the termination of the Fourier–Bessel integral.

Electron microscope studies[6] have shown that the ribonucleic acid in tobacco mosaic virus is located near the particle axis. From the present work alone it is not possible to decide at what radius the ribonucleic acid is located. This question is resolved by comparison of this density distribution for the normal virus with that for the ribonucleic acid – free virus protein, described by Dr. R. E. Franklin in the following communication.

Details of this work, which was supported in part by a grant from the U.S. National Science Foundation, will be described elsewhere.

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Location of the Ribonucleic Acid in the Tobacco Mosaic Virus Particle

In the rod-shaped particle of tobacco mosaic virus, the protein is in the form of sub-units set in helical array about the long axis of the particle[1]. Electron microscope studies[2] have indicated that the virus nucleic acid may form an axial core. In this com-

munication, however, a brief account is given of an X-ray diffraction investigation which provides strong evidence that the nucleic acid in the intact virus particle does not lie very close to the particle axis. The nucleic acid seen as a core in electron micrographs of partially degraded tobacco mosaic virus is therefore presumably in a collapsed form.

Using monochromatic copper $K\alpha$ radiation and a high-resolution focusing X-ray camera, measurements have been made of the scattered intensities on the equator and layer-lines of X-ray fibre-diagrams of orientated gels of the following substances: (1) tobacco mosaic virus, normal strain, prepared by Dr. H. Fraenkel-Conrat; (2) a mercury-substituted tobacco mosaic virus containing one mercury atom per 20,000 molecular weight of protein, prepared by Dr. H. Fraenkel-Conrat; (3) repolymerized *A*-protein prepared by Prof. G. Schramm[3]. This material is obtained from a normal strain of tobacco mosaic virus by breaking down the virus in weak alkali, removing the nucleic acid by electrophoresis, and repolymerizing the protein by lowering the *p*H.

A few non-monochromatic measurements were also made on a mercury-substituted repolymerized *A*-protein prepared by Dr. H. Fraenkel-Conrat.

The above materials, although prepared in two different laboratories, were all obtained from 'normal' virus strains. All normal strains of tobacco mosaic virus which we have so far examined give X-ray diagrams which are almost indistinguishable from one another. Moreover, our equatorial intensities, obtained photographically, are in excellent agreement with Caspar's data[4] obtained with a Geiger counter and a different virus preparation. Quantitative comparisons of diffraction data obtained from the materials listed above are therefore justified. The main purpose of this communication is to report such a comparison of accurate measurements on the normal tobacco mosaic virus and the repolymerized *A*-protein preparations (1 and 3 above).

It has previously been shown[5] that the X-ray fibre-diagram of repolymerized *A*-protein resembles that of tobacco mosaic virus so closely that there can be no doubt that the structural arrangement of the protein characteristic of the virus is preserved in the repolymerized protein. There are, however, important points of difference in the two diagrams. These are most marked on the equator, but are significant also on all the layer lines which can be accurately measured. It is from a study of these differences that the location of the nucleic acid in the tobacco mosaic virus particle can be determined.

Before discussing the differences between the tobacco mosaic virus and repolymerized *A*-protein diagrams, however, it is necessary to mention some results obtained from a comparison of the normal and the mercury-substituted virus, that is (1) and (2) above (Franklin, R. E., and Holmes, K. C., unpublished results). This has both served to confirm Caspar's allocation of signs[4] to the equatorial intensity maxima of the normal virus, and led to a new determination (Franklin, R. E., unpublished results) of the hitherto somewhat uncertain parameters of its helical structure[1,6]. This makes it possible to make the comparison between tobacco mosaic virus and repolymerized *A*-protein by two independent methods.

In the first method, the intensities recorded on the layer-lines for the two materials were compared. Using the newly determined parameters of the helical structure of the virus it can be shown that, on each of the first eight layer-lines, the principal difference between the X-ray diagrams of tobacco mosaic virus and repolymerized *A*-protein must be attributed to a structural difference at a radial distance of about 40 A. from the particle axis. This strongly suggests that the nucleic acid in tobacco mosaic virus is situated in this position.

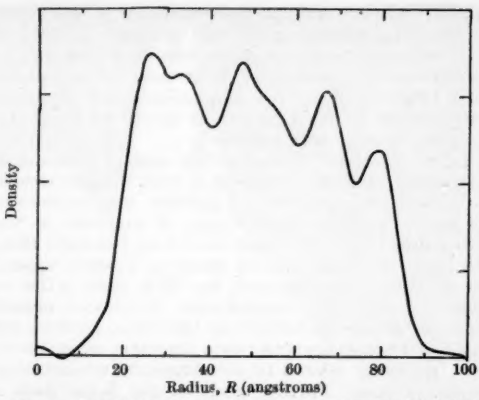

Fig. 1. Radial density distribution in repolymerized, nucleic acid-free tobacco mosaic virus protein. Ordinates are proportional to the excess electron density of the protein over that of water. Note that the density maximum observed at 40 A. for the complete virus (ref. 4) is here replaced by a density minimum

The second method is independent of the helical structure of the virus. The radial density distribution in repolymerized *A*-protein has been calculated by means of the Fourier–Bessel transform of the equatorial amplitudes. Amplitudes for values of $2\sin\theta/\lambda$ up to 0·1 were used for this purpose. It was found possible to determine the signs of the amplitudes unambiguously in this range by comparing the intensity data with those for tobacco mosaic virus on one hand, and mercury-substituted repolymerized *A*-protein on the other. To eliminate or reduce spurious peaks in the transform, an 'artificial temperature factor' of $\exp\{-(11{\cdot}8 \times 2\sin\theta/\lambda)^2\}$ was imposed on the amplitude data. The resulting radial distribution function is shown in Fig. 1.

This distribution bears sufficient resemblance to the density distribution of tobacco mosaic virus calculated by Caspar[4] to show once again (cf. ref. 5) that the structural arrangement of the protein in the two materials is very similar indeed. (Some minor points of difference between the two curves may be attributed to the different cut-off position used and to the use of an 'artificial temperature factor' for the repolymerized *A*-protein. For example, the small peak at 53 A. in Caspar's curve is a spurious maximum resulting from the sharp cut-off at $2\sin\theta/\lambda = 0{\cdot}094$.) But there is one striking difference between the two curves. Whereas tobacco mosaic virus has its strongest density *maximum* at a radial distance of 40 A., repolymerized *A*-protein has a pronounced *minimum* at just this position. The radial density distribution in the protein thus provides strong confirmation of the conclusion, reached independently from a study of the layer lines, that the principal structural difference between tobacco mosaic virus and repolymerized *A*-protein occurs at a radius of 40 A. The strong density maximum at 40 A. in tobacco mosaic virus must therefore be due to the presence of nucleic acid at this radius.

In X-ray scattering by nucleic acids, the phosphate group of the nucleotides acts effectively as a 'heavy

atom'. X-ray studies of deoxyribonucleic acid have shown[7] that scattering by this compact group can have an effect which predominates over that due to the rest of the nucleotide. It is thus the phosphate back-bone chain of the ribonucleic acid molecule which must lie on a radius of about 40 A. in the tobacco mosaic virus particle.

It will be noted that the first density maximum, at a radius of 25 A., is present in both tobacco mosaic virus and repolymerized *A*-protein, and represents an approximately equal weight of material in the two substances. We must therefore conclude that, whereas the 40-A. density peak in tobacco mosaic virus is due to nucleic acid, the 25-A. peak is due to protein. Thus the nucleic acid in tobacco mosaic virus is deeply embedded in the virus protein. Its molecular structure and chain direction must therefore be closely related to the structural arrangement of the protein. Further study of the X-ray data is in progress with the view of determining how many nucleic acid chains the tobacco mosaic virus particle contains, and in exactly what direction they run.

The work summarized above will be described in detail elsewhere. I am most grateful to Dr. H. Fraenkel-Conrat and to Prof. G. Schramm for supplying me with the tobacco mosaic virus and virus derivatives used in this investigation. The work was supported by the Agricultural Research Council.

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PROPAGATION OF AUDIO-FREQUENCY RADIO WAVES TO GREAT DISTANCES

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THE propagation of low-frequency radio-waves was studied many years ago using long-wave commercial transmitters. The well-known Austin–Cohen law was widely used for estimating field-strengths, and because of the theoretical justification of its general form this law was used as a basis for the computation of attenuation coefficients at very low frequencies. According to the law, the attenuation of signals decreases as the frequencies decrease; in fact, at a frequency of 3 kc./s. or less, the attenuation would appear to be very small indeed. The absence of observations at frequencies less than about 12 kc./s., however, meant that the mode of propagation of radio waves at lower frequencies was for many years the subject of speculation.

Now in the course of our observations on the electromagnetic waves radiated by lightning discharges, we have found evidence of a high attenuation of waves in the frequency-range of 2–3 kc./s., in complete contradiction to that predicted by the Austin–Cohen law.

In the original observations on these naturally-occurring disturbances known as atmospherics[1], it was found that they acquired characteristic patterns during their passage between the ground and the ionosphere. An inspection of their wave-forms up to very considerable distances from the source clearly showed that the main concentration of energy lay in the audio-frequency band below 10 kc./s. and that the higher-frequency components moved forward relative to the lower-frequency or 'slow tail' components as the distance of propagation increased. Furthermore, it was observed that a band of frequencies in the neighbourhood of 2 kc./s. was either entirely missing or at least very heavily attenuated. This band of missing frequencies lay between the predominant frequency of the characteristic 'oscillatory head' and the 'slow tail' of the atmospheric and, as was stated earlier[1], unless there is some factor operative corresponding to anomalous dispersion for the missing frequencies, the higher-frequency group and the slower disturbance do not originate in exactly the same portion of the discharge.

It is pertinent to remark here that Eckersley in his early studies of radio-transmission[2] questioned the continued validity of the Austin–Cohen law with decreasing frequency of the wave. In fact, he suggested a theoretical reason for supposing that the attenuation ceases to decrease at frequencies lower than about 12 kc./s.

In order to elucidate this problem, we have, during the past few years, supplemented atmospheric wave-form observations by simultaneously recording the relative amplitude of the frequency components in the spectrum of the wave-form. In their first experiments, Chapman and Edwards[3] recorded the wave-forms and corresponding response of a number of narrow-band receivers tuned to frequencies in the range 1–25 kc./s. The amplitude of the various frequency components was calculated from these responses and the observed spectrum of atmospherics due to lightning strokes between the cloud and ground compared with that to be expected from this type of discharge. Later, Chapman and Matthews[4] used an improved apparatus covering the frequency range 40 c./s. to 16 kc./s. split by twenty-seven band-pass filters arranged logarithmically at three channels per octave. Here the amplitude-frequency spectrum was presented directly on the screen of a cathode-ray tube and photographed along with the corresponding wave-form. They discussed the relation between the well-known wave-form characteristics and the significant changes in the spectrum as the distance of propagation increases.

In our more recent experiments we have applied magnetic tape sound-recording techniques[5] to obtain permanent records of the complete history in time of all the disturbances appearing at the aerial (a vertical rod). A second channel on the tape, linked by telephone line to the Meteorological Office C.R.D.F. network for locating thunderstorm centres, provides information on the source of individual

atmospheric disturbances. The random distribution of the different types of atmospheric and their amplitude in relation to the continuous background noise-level at the site can thus be readily assessed. The spectrometer has also been modified to record single waveforms and their amplitude-frequency-spectra at a maximum rate of one record per second, and an electronic switching device ensures that spurious signals do not add to the spectrum recorded.

The results to be described are based on one particular type of atmospheric, namely, that resulting from cloud-to-ground discharges and at known distances up to about 4,000 km. Observations have been made under both day and night conditions of propagation and at different seasons of the year. The attenuation coefficient of signals in the frequency range 40 c./s. to 16 kc./s. has been computed from the experimental results for both land and sea paths and different ionospheric conditions. In all cases the presence of a marked absorption band has been found at a frequency of 1 or 2 kc./s. Finally, the results obtained are compared with the earlier long-wave transmission results and the more recent theories of propagation.

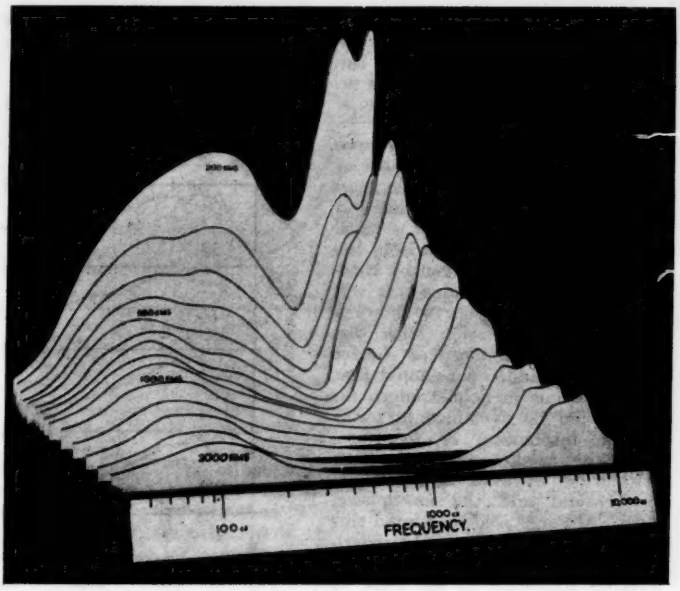


Fig. 1. Model showing the relative amplitude of the frequency components of atmospherics resulting from an average cloud-to-ground lightning stroke observed by day at different distances from the source. The vertical scale shows relative amplitudes in micro-volt, sec./metre (1 cm. in the model corresponds to 10 micro-volt, sec./metre)

In Fig. 1 is shown a photograph of a model illustrating the way the spectrum of the disturbance radiated by an average cloud-to-ground lightning stroke varies with the distance of propagation. This particular model was constructed from a large number of observations made on land sources at noon during winter months. It clearly shows that with increasing distance the various frequency components, besides falling off in amplitude due to a two-dimensional divergence of energy, also suffer selective attenuation due to ionospheric influences as had previously been reported by Appleton and Chapman[1]. The preponderance of energy in the highest and lowest frequency-ranges represents the familiar 'oscillatory head' and 'slow tail' parts of the wave-form, respectively.

It is not our purpose to discuss here the various types of disturbance and their characteristic spectra; but it should be mentioned that frequently the 'slow-tail' components are either absent or at least very small. This is undoubtedly an effect of the source dependent on the mode of destruction of the thunder-cloud charge by the lightning stroke, that is, whether or not the current in the discharge channel rapidly decreases after the 'return stroke' has reached the cloud[6]. However, in all cases of both high- and very low-frequency radiation at the source, there is an absorption band in the spectrum of the distant atmospheric which is clearly the result of propagation. This phenomenon, together with the law of propagation at these very low frequencies, are the subject of our present discussion.

In dealing with our experimental results, we are faced with two problems. What is the strength of the signal radiated at the source on any particular frequency channel, and how does propagation affect the amplitude of the signal observed on this channel at a distance? It will be seen that we cannot interpret our observations without some knowledge of one or the other.

The diverse nature of lightning discharges makes it difficult to derive any useful data on the spectrum of the radiation field at the source, although some information already exists for a simple type of discharge[2,7]. However, as regards the effect of propagation, it is possible to be more definite.

It is well known that electric waves of very low frequency are guided around the earth by the ionosphere and, as already indicated, many attempts have been made, both empirical and theoretical, to derive expressions for the signal-strength $E(f,r)$, where f is the frequency and r the distance of propagation. A survey of the extensive literature on the subject indicates that the main contribution to the signal-strength may be represented by an expression of the form

$$E(f,r) = A(f)r^{-1/2} \exp [- \alpha(f)r]$$

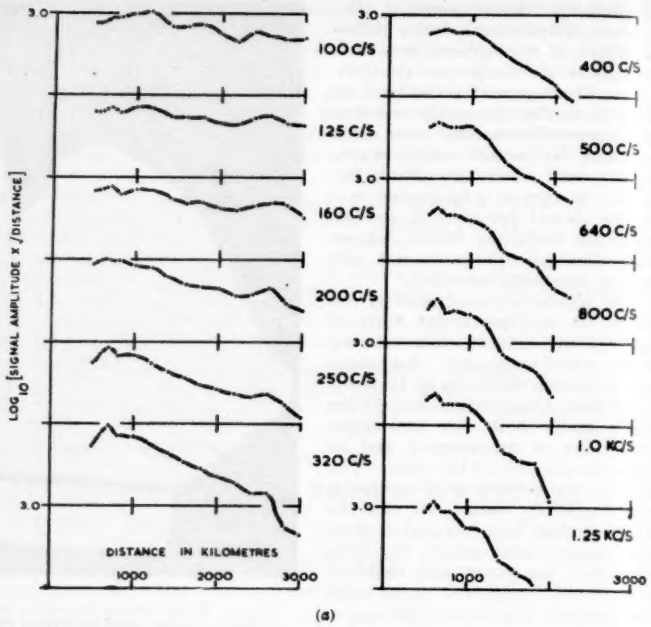
(200 km. $< r <$ 3,000 km.), where $A(f)$, the amplitude coefficient, depends on the spectrum at the source and $\alpha(f)$ is the attenuation coefficient.

This is essentially the formula used by Round, Eckersley, Tremellen and Lunnon[8] for the interpretation of their observations on the propagation of signals from long-wave transmitters (frequencies down to 12·5 kc./s.), and as will be seen later, there are good grounds for assuming that the formula may be applied at much lower frequencies.

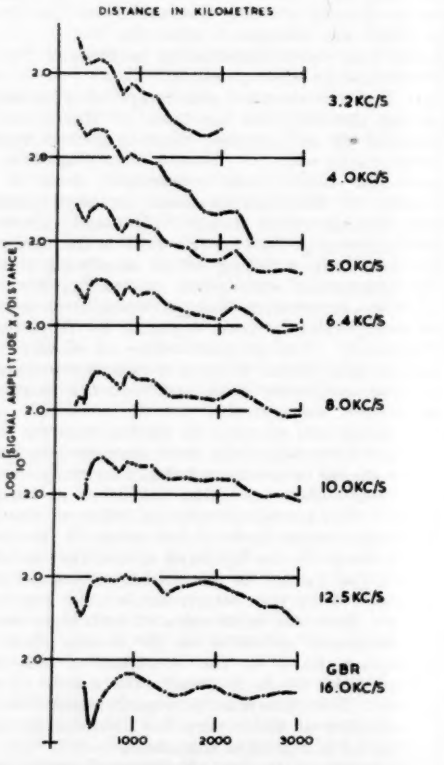
According to the above expression, the value of the quantity $\log [E(f,r)r^{1/2}]$ at any particular frequency varies linearly with the distance r, so that the value of the attenuation coefficient $\alpha(f)$ at that frequency can be determined directly from the slope of the line obtained by plotting the results in this

way. This was the method used by Round and Eckersley[8] and later by Budden[9] in his discussion of the measurements made by Weekes on the field-strength of the 16 kc./s. Rugby transmitter *GBR*.

In Fig. 2 (*a*) and (*b*) we have plotted our results for a number of frequency components derived from the spectrum of atmospherics and ranging from a frequency of 100 c./s. to 12·5 kc./s. For comparison, the corresponding curve given by Budden[9] for *GBR* is included. It will be seen that each curve shows a characteristic variation with distance more pronounced at shorter distances. Budden considered that the variations in field-strength for *GBR* could be explained in terms of the interaction of two predominant modes of propagation in the wave-guide bounded by the ground and the ionosphere. Ya L. Al'Pert[10] also calculated this kind of variation of signal-strength with distance for *GBR*. The striking similarity in the form of the curves derived at lower frequencies using atmospherics and that measured by Weekes and Budden for *GBR* transmissions is to be noted. Also, the results for frequencies less than 1·5 kc./s. do not show this effect so markedly.



(*a*)



(*b*)

Fig. 2 (*a*) and (*b*). Variation with distance of log $E(f,r)r^{1/2}$ at different frequencies. (The interval between horizontal lines represents one unit on the logarithmic scale)

Evidently, by smoothing out the effect of the secondary modes of propagation, the mean slope of the straight line obtained for each channel gives a value for the attenuation coefficient of the principal mode or main signal contribution on that channel. The values of $\alpha(f)$, expressed in decibels per 1,000 km. path, are plotted against frequency in Fig. 3 for both day and night conditions of propagation, the experimental values for which are marked by circles and crosses, respectively. The values of the attenuation coefficient over the frequency-range 20–30 kc./s. as measured by Eckersley[8], using signals from long-wave transmitters, are shown for comparison. These follow fairly closely the Austin–Cohen law of attenuation, which predicts a progressive decrease in the value of $\alpha(f)$ as the frequency is lowered but fails to account for the remarkable increase in attenuation at about 10 kc./s. to a maximum value at a frequency of two or three kilocycles per second. The propagation path, in fact, exhibits selective absorption, which, together with the low attenuation at the extreme ends of the audio-frequency range, accounts for the observed long-distance propagation characteristics of atmospherics[1]. As is to be expected, the attenuation at all frequencies is greater by day than by night, but the difference between the day and night values is greatest in the region of maximum absorption.

We recall here the experiments of Gardner[11], who recorded the integrated noise-level of atmospherics using four receivers tuned to different frequencies between 3·5 and 50 kc./s. Gardner found that the ratio of the day to night noise-level was less at 3 kc./s. than at 10 kc/.s., from which he inferred that the onset of daylight conditions gave a marked increase of attenuation for frequencies less than 10 kc./s. These conclusions were confirmed by

Bowe[12]. From our observations, it is clear that the greatest increase in attenuation occurs at a frequency of about 2 kc./s., it being then about 10 db. greater than at either 10 kc./s. or at 200 c./s.

It is of interest now to compare our results with those predicted by Budden, assuming propagation in a 'waveguide' bounded by a perfectly conducting Earth and an imperfectly conducting sharply bounded ionosphere. The full-line curves *A* and *B* in Fig. 3 are those derived by Budden[13] for the different ionospheric parameters quoted. The attenuation coefficient so calculated as a function of frequency relates to the zero-order mode of propagation, as do our experimentally determined values. The parameter p_r depends on the ratio N/ν where for the upper boundary there are N electrons per c.c., and these are assumed to make an average of ν collisions per second. The orders of magnitude of N and ν for the region in question are 10^3 cm.$^{-3}$ and 10^7 sec.$^{-1}$, respectively; but, as Budden has pointed out, although a small change in p_r does not result in any marked change in the form of his curves, changes in the value of h (the height of the upper boundary) have an appreciable effect. It is also known that the height of reflexion of very long waves is greater at night than by day, and the general agreement between the theoretical and experimental values of $\alpha(f)$ both substantiates the waveguide theory and the experimental method followed in this work. Moreover, the appropriate value of h for these very low-frequency waves can be inferred from the measurement of their attenuation.

The attenuation curves shown in Fig. 3 were derived from atmospherics originating in European storm centres and relate to propagation over the ground. A difference, however, has been found for Atlantic sources giving an appreciable sea-path, the most striking difference being the improved transmission of signals at the higher frequencies, particularly in the region of 5 kc./s. This is undoubtedly an important factor in determining the characteristic type of atmospheric observed from Atlantic sources. Further, the diurnal and seasonal differences in propagation, which will be dealt with elsewhere, clearly follow changes in the ionosphere. For all ionospheric conditions the same type of attenuation curve is obtained. There is a marked selective absorption band, and this is associated with a discontinuity in the group velocity of the waves. Calculations have shown that the group velocity of the atmospheric 'slow tail' component is less than that for the higher-frequency 'oscillatory head', and that in the neighbourhood of the absorption band the group velocity decreases rapidly.

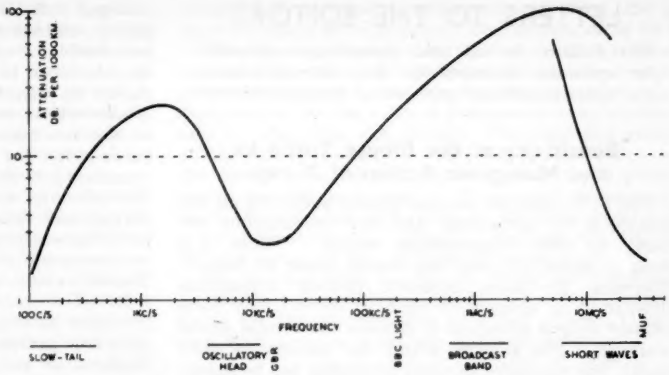


Fig. 4. Variation of attenuation with frequency. The curve for the frequency range 30 kc./s. to 30 Mc./s. is taken from Eckersley (ref. 2, Fig. 31)

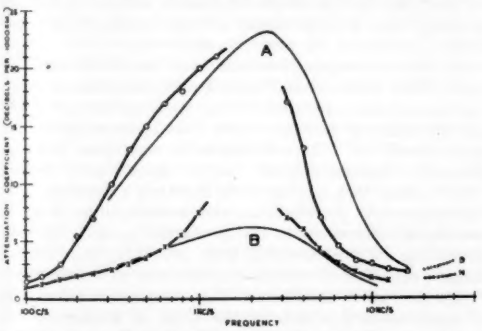


Fig. 3. Variation of attenuation coefficient with frequency for propagation over the ground

—○—○—, Day-time values; —×—×—, night-time values compared with the theoretical curves for different ionospheric parameters; *A*, ionospheric height, $h = 50$ km., $p_r = 6 \times 10^6$ sec.$^{-1}$, and *B*, for $h = 80$ km. and $p_r = 2 \times 10^5$ sec.$^{-1}$. Eckersley's values, ...; *D*, day, and *N*, night

Finally, in Fig. 4, we link the results of the work now described with the attenuation curve for long-distance day transmission of radio signals of frequency up to about 30 Mc./s. as given by Eckersley[2]. This curve gives a fair idea which waves are the least attenuated and can travel to the greatest distances. It is a remarkable property of the ionosphere that extremely low-frequency waves less than two or three hundred cycles per second only suffer the same small attenuation as that assigned to the short waves so extensively used in world-wide communication.

The work described here was carried out with the co-operation of the Meteorological Office Sferics Organization for the location of the sources of atmospherics, and without which the investigation would not have been possible. We gratefully acknowledge our indebtedness to the Director of the Meteorological Office and his staff, also to the Department of Scientific and Industrial Research for a grant to cover the cost of equipment.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Sensitivity of the Mouse Testis to the Mutagenic Action of X-rays

Dr. C. Auerbach is a recognized authority on the induction of mutations, and her publications are likely to carry considerable weight. There is a danger, therefore, that the recent letter in *Nature*[1] (claiming to have detected greater mutational sensitivity in spermatids than in sperm) may have greater weight attached to it than the results would warrant. The authors admit the paucity of their data; but a number of other criticisms can be made.

The usual method of classifying sperm samples in the mouse is by time from irradiation rather than order of the litters conceived by it. This is the classification used by Russel and Hertwig, with whose results Auerbach and Slizynski compare their own. It would be of interest, therefore, to learn whether the alternative classification of these data gives the same picture of variation in sensitivity.

The class sizes are rather small for the χ^2 test to be applied to the variation due to the order of litters, but this yields a χ^2 of 5·8056 for 7 degrees of freedom, which is non-significant ($P = > 0{\cdot}5$). Drs. Auerbach and Slizynski have crammed a large part of this non-significant χ^2 into 1 degree of freedom which they have selected as giving the maximum difference between two groups.

Finally, if more extensive observations did confirm their empirical conclusions, there would remain the question of interpretation. Auerbach and Slizynski expected to find spermatids more sensitive than mature sperm. Thus, when they believed they had found an ultra-high mutation-rate in the fifth and sixth litters, they assumed that these represented the irradiation of spermatids and that their three-week mating period represented at least all post-meiotic stages. But this is most unlikely. My own work (unpublished) has shown that following a dosage of 200 r., male mice remain fully fertile for five weeks, throughout which period dominant lethals are detectable. After a sterile period of about one week, full fertility is restored without dominant lethals. Thus the interval from meiosis to the utilization of the sperm initiated at that meiosis is about six weeks, and Auerbach's and Slizynski's samples, as those of other workers using doses of 400–600 r. and higher, were probably confined to irradiated sperm or at most late spermatids. Presumably spermatids irradiated with the higher doses fail to produce viable sperm.

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We are grateful for the opportunity of replying to Dr. Bateman's criticism.

(1) The main and most pertinent of his objections is levelled against the small scale of our experiment. We fully agree with him on this point. We thought we had made this clear when we described our work as a "pilot experiment", for which "confirmation on a larger scale is desirable". It is true that, from a purely statistical point of view, it would not be permissible to apply a test of significance to a difference between two parts of a series which as a whole shows no significant deviation from homogeneity. Nevertheless, we felt justified in applying such a test to the two non-overlapping groups of points in our curve; for our working hypothesis had been that translocation frequency would show just such a discontinuity about midway through the presterile period, and that the change would be from a lower to a higher frequency. We based this expectation on the much more extensive work by Hertwig[2] and Russel[3], which clearly shows that, after irradiation with either X-rays or neutrons, dominant lethality is higher in the late than in the early stages of the presterile period. Since with the doses used by these workers 30 per cent or more of dominant lethals presumably are due to inviable translocations, it would indeed be unexpected to find that translocations do not follow the same trend. The fact that our results agreed with expectation was taken to reinforce the findings on dominant lethals and, together with these, furnish 'presumptive evidence' for a varying degree of sensitivity in post-meiotic stages of spermatogenesis. Again we thought we had made this clear in our communication.

The remainder of Dr. Bateman's objections are based on his own observations. Since these have not been published and are only vaguely hinted at in his communication, we could not, and cannot now, take account of them. Whatever the nature of these observations, they appear to contradict results by Snell, Hertwig, Russel and others[3]. Admitting the possibility that Dr. Bateman's newer data may make a re-assessment of the older work necessary, we can at the moment base our conclusions only on these older, generally accepted results.

(2) We considered that the number of copulations would be a better measure of sperm utilization than time after irradiation. For *Drosophila*, Dr. Bateman himself has shown[4] that sexual activity, more than time, determines rate of sperm utilization. For the mouse, Hertwig has shown the same[1]. In fact, however, there is scarcely any difference between the grouping of our data by time or by litter number. All litters in our first group were conceived between the first and eleventh day after irradiation, and the remainder between the eleventh day and the onset of sterility in the third or fourth week. The only overlap was a fifth litter of one male, which had been conceived on the eleventh day.

(3) Russel[3], basing himself on all available evidence up to 1954, states that "there is now almost unanimous agreement that spermatocytes, spermatids and sperm are resistant to radiation and that spermatogonia are quite sensitive". In a footnote he mentions that also primary spermatocytes "show appreciable sensitivity", and this agrees with Hertwig's opinion. We therefore felt justified in the assumption that, by testing all litters from the presterile period, we were sampling all post-meiotic and, possibly, late meiotic stages, and that therefore the increase in translocation frequency after the fourth litter was due to admixture of spermatozoa which at the time of treatment had not yet reached maturity. Whether these immature stages should be called "spermatids", or "late spermatids" (as Dr. Bateman does), seems a secondary question, which cannot be decided on the present evidence. The relevant point is the existence of a stage in spermatogenesis, prior to complete matura-

tion of the sperm and probably after meiosis, which is more sensitive than mature spermatozoa. The only alternative to this interpretation is that the amount of chromosome damage is increased in irradiated mature spermatozoa which are stored in the testis. This possibility has been considered by Hertwig, who tested and rejected it on the evidence of experiments in which irradiated males were kept for seventeen days before their first matings.

(4) Dr. Bateman seems to give much weight to the observation that in his own experiments with 200 r. the presterile period and one week of sterility together extended over six weeks. However, the length of the presterile period varies considerably between experiments (see Table 12–1 in ref. 3) and is certainly, as established by Hertwig, dependent on the amount of sexual activity of the males. The length of the sterile period varies even more between experiments and is determined mainly by the dose and the correlated more or less severe damage to spermatogonia. The sum of these periods is therefore not suitable for determining the time interval between meiosis and the availability of mature sperm. This interval is almost certainly much shorter than six weeks, as shown by older histological observations (see ref. 3) as well as by newer work with labelled phosphorus[5].

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A Convulsant Alkaloid of *Dioscorea dumetorum*

An alkaloid, dioscorine, has been isolated from various species of yam of the family Dioscoreaceae. Pinder[1] has summarized the history of this, confirmed its molecular formula as $C_{13}H_{19}O_2N$ and has documented certain of its chemical and physical properties[2]. A similar alkaloid has been extracted from a further species common in the wild state in Nigeria and identified by its botanical characteristics and typically small starch grains as *Dioscorea dumetorum* (Yoruba name, èsúru[3]).

The latter alkaloid has not been obtained crystalline, but has been extracted and purified by various procedures; together with its crystalline salts, its analysis supports the formula $C_{13}H_{21}O_2N$. Its infrared and ultra-violet spectra differ from those reported for dioscorine. Thus the *D. dumetorum* alkaloid shows a single absorption maximum at 2080 A. on a calibrated 'Unicam' spectrophotometer as compared with a maximum at 2170 A. reported for dioscorine. The chemistry of the former is being further investigated.

When injected into mice, the alkaloid of *D. dumetorum* acts as a convulsant poison. The convulsions are usually clonic at first, later tonic and may be followed either by death or recovery. When injected by the intra-peritoneal route, using a freshly prepared 1 per cent aqueous solution, the *LD*50 is approximately 65 mgm./kgm. Concentrations of 10^{-5} reduce the response to acetylcholine on the isolated guinea pig ileum and isolated rabbit duodenum preparations. At a dose-level of 20 mgm./kgm. the responses of the cat's blood pressure to acetylcholine and to adrenaline are altered. The depressor effect of the former is reduced, and the pressor effect of the latter is enhanced. No local anæsthetic effect could be demonstrated. Dioscorine[2] apparently lacks atropine-like properties in the concentrations mentioned above, nor does it potentiate the action of adrenaline on the cat's blood pressure.

We are indebted to Mr. B. Reiff for technical assistance. Grants from the Nigerian Government Fund for the Investigation of West African Drugs and Medicines are gratefully acknowledged.

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Aminomalonic Acid Decarboxylase: a New Enzyme

Aminomalonic acid was first described by Baeyer[1] in 1864, who found that heat treatment converted the amino-acid smoothly into glycine. Knoop[2] suggested the intermediary formation of aminomalonic acid in the biological formation of glycine from serine. But Haas[3] could not find evidence that it is a precursor of glycine in the rabbit, either in experiments on the whole organism, or in the isolated liver, or with liver homogenate. Shemin[4] has claimed to have excluded aminomalonic acid as an intermediate in the metabolic change of serine to glycine from results obtained by isotopic studies. However, this view was criticized by Ogston[5].

In the present communication, we report the presence in animal tissues of an enzyme which catalyses the decarboxylation of aminomalonic acid to glycine. This enzymatic activity was first observed in the homogenate of silk-gland tissue and afterwards in rat-liver homogenate.

The enzyme solutions used in the present work were prepared by homogenizing the posterior silk-glands of silkworms at the fifth instar with 3 vol. of 0·15 *M* potassium chloride and centrifuging off the undissolved material. The test system contained 0·5 ml. of aminomalonic acid solution (88 μmoles per ml., ammonium salt), 1·0 ml. of phosphate or acetate buffer and 1·0 ml. of the enzyme solution.

The rates of the reaction were followed in two ways. In one procedure the determination of carbon dioxide production was carried out with the conventional Warburg manometric apparatus. The amount of glycine formed was also determined. Aliquot samples were taken from the reaction mixtures and deproteinized by the addition of one-third volume of 95 per cent alcohol and boiling for 1 min. in the water-bath. The filtrates were assayed for

glycine by a quantitative paper chromatographic technique. The glycine formed was also identified as its 2,4-dinitrophenyl derivative.

The activity of this enzyme solution, expressed as μl. carbon dioxide formed per hr. per 250 mgm. fresh tissue, was about 80. The rate of the reaction was found to be proportional to the time of the reaction over a period of 90 min. under the conditions employed, showing that the kinetics of this reaction is zero order for a limited time. The Michaelis constant was determined as $6 \cdot 5 \times 10^{-3}$ *M*.

The *p*H optimum for the decarboxylation of aminomalonic acid was found to be at 5·9–6·1. The crude enzyme solution did not decarboxylate malonic acid, aspartic acid or glutamic acid.

When the crude enzyme solution was held at 70° for 10 min. or at 100° for 5 min., enzyme activity was entirely destroyed. Several inhibitors were tested, and it was found that the enzyme activity was inhibited completely by hydroxylamine at a concentration of 10^{-3} *M* and also by potassium cyanide at a concentration of 10^{-2} *M*.

The activation energy of this enzyme – substrate system was determined over the temperature-range 27°–42°, and found to be about 14,600 calories. This value is considerably lower than that for non-enzymatic decarboxylation in the system 0·3 *N* sulphuric acid – aminomalonic acid.

The activity of this preparation was not affected by dialysis against distilled water for three days at 0°–4°. The enzyme was partially purified by fractionation with ammonium sulphate and absorption on and elution from aluminium hydroxide *C*γ and the product was about thirteen times as active as the starting material.

Our results indicate that the decarboxylation of aminomalonic acid takes place by the action of a new enzyme which we propose to call 'aminomalonic acid decarboxylase'.

This work is continuing and will be reported in full elsewhere.

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New Amino-Acid – Glycosides isolated from Tryptic Hydrolysates of Milk Products

The protein – sugar complex formed by interaction between the free amino-group of protein and reducing sugar recently became of interest to food chemists as the first intermediate in the amino-carbonyl (or Maillard) reaction of those systems. The formation of such a protein – sugar complex in milk products, for example, heated milk and dried skim milk, has been confirmed by Henry *et al.*[1] and Patton *et al.*[2] respectively. On the other hand, it has been known that carbohydrate is contained in casein and bound with the amino-acid residue of it in the form of glycoside[3,4]. In consequence, it seems reasonable to assume that carbohydrate can exist in these protein materials either as preformed or as secondarily formed glycoside.

Table 1

	Amino-acid – glycosides	
	I	II
Hydrolysed products by 6*N*-hydrochloric acid	Glucose Galactose	Galactose
Colour reaction with developer: Benzidine	Positive	Positive
Colour reaction with developer: Resorcine	Negative	Positive
Colour reaction with developer: Ninhydrin	Positive	Positive
Hydrolysed products by β-glucosidase	Galactose	Galactose
Alkaline methylamine reaction (for 1 ~ 4-bond) (ref. 7)	Positive	Positive
Cystein-carbazol reaction (for ketose) (ref. 8)	Negative	Positive

While the chemical behaviour of the preformed protein – sugar complex, that is to say, mucoprotein and mucopolysaccharide, and the formation of secondary complexes are now well known, the chemical properties of the complex have not so far been investigated in any detail. The present experiments refer to the isolation and identification of amino-acid – glycosides which are the fundamental constituents of the secondarily formed protein – sugar complex in milk products.

The amino-acid – glycosides were isolated from the tryptic hydrolysates of evaporated milk and dried skim milk by the procedure of Inoue *et al.*[3], and Masamune *et al.*[4], except that the large-scale multiple paper chromatogram was used for purification of the crude material. The developed paper was sprayed with aniline hydrogenphthalate and ninhydrin reagents. The chromatograms gave three spots (I ~ III) corresponding to amino-acid – glycosides. The R_g values calculated from four chromatograms of I, II and III showed, respectively, 0·21, 0·55 and 0·87.

To confirm the presence of these compounds in milk protein, casein[5] and whey protein isolated by the method of Kondo *et al.*[6] were used to prepare amino-acid – glycosides according to the procedure described. Paper chromatograms from both these substances gave essentially the same spot, corresponding to III. The most reasonable conclusion to be drawn from these results is that I and II are secondarily formed glycosides, and that III is originally present in raw milk.

On the basis of the results shown in Table 1, it is suggested that the carbohydrate constituents of glycosides I and II were β-galactosyl-α-glucoside (lactose) and β-galactosyl-1-deoxy-α-fructoside (lactulose), respectively. The liberation of these disaccharides from the glycosides by treatment with 'Amberlite *IRA*-410' in the H^+ form confirmed the presence of these glycosidic linkages in them. The presence of the disaccharide of I and II in the eluate was proved by comparison with corresponding standard compounds.

The aglycones of these materials were liberated without decomposition of the peptide bonds by treatment with *N* hydrochloric acid. As paper chromatograms sprayed with ninhydrin gave a spot of the same R_F for various solvents, it seemed that the aglycones of I and II are identical and are derived from the same secondarily formed protein – sugar complex in the milk products. The constituent amino-acids of the aglycones were histidine, alanine, lysine, leucine, with traces of glutamic acid, aspartic acid, serine and valine. Accordingly, it may be con-

cluded that I is converted to II in accordance with the Amadori rearrangement, and that this rearrangement is carried out on the glucose residue bound to the amino-radical of the aglycone. It may also be seen that the terminal amino-acid of aglycone bound to those carbohydrates is lysine derived from casein as shown by some workers[9,10].

I wish to thank Profs. R. Sasaki and T. Nakanishi for advice and criticism. These investigations are being continued, and a full account will be published elsewhere.

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Oxygen Consumption and Active Transport of Sodium in the Isolated, Short-circuited Frog Skin

For the isolated, short-circuited frog skin with Ringer solution on both sides, it has been found that the active transport of sodium is equal to the current required to reduce the potential difference across the skin to zero[1,2]. It is also a well-known fact that the active transport of sodium depends on the oxygen supply to the skin. Francis and Pumphrey[3] found that oxygen-free Ringer solution caused an irreversible disappearance of the potential difference across the skin in the course of 20–40 min.

It was the purpose of the present study to investigate the relation between sodium transport and the oxygen consumption in the frog skin (*Rana temporaria*). In principle, the apparatus employed was the same as that used by Ussing and Zerahn[1]; but it was made exclusively of glass, since Andersen and Lehmann (personal communication) have found that 'Perspex' is not suited for such investigations. The solution was circulated by the action of a magnetic field on an iron core sealed into glass. The apparatus was assembled with the frog skin placed between the two halves, filled with the required solutions and closed by means of two ground joints greased with silicone.

The oxygen determinations on the solutions were made by the Winkler method as modified by Krogh[4].

The compartment on the inside of the skin was filled with Ringer solution to which vasopressin was added in some experiments in order to increase the sodium transport and hence the oxygen consumption. During the actual experiment the compartment on the outside of the skin is filled with Ringer solution. In this way, the sodium transport can be recorded by reading the short-circuiting current, and the oxygen contents of the solutions can be determined before and after the experiment. This procedure gives the total oxygen consumption and sodium transport.

However, one cannot expect that all the oxygen will be used for active transport of sodium, and the oxygen consumption was therefore also measured when no sodium transport occurred. This is done most easily by removing the sodium ions from the outside compartment by replacing the Ringer solution with distilled water. The oxygen then consumed by the skin is not used for sodium transport and may be subtracted from the total oxygen consumption as a blank.

Control experiments were performed before and after the sodium transport experiment. All the measurements were made on the same skin, and the skin was cut free and weighed after the last control period. Oxygen consumption and sodium transport were both expressed in μequivalents/hr. in order to make them directly comparable. Control runs with the apparatus filled with Ringer solution and secured with silicone grease instead of mounting a frog's skin showed that the oxygen concentration of the solution in the apparatus did not change during 2 hr. (the usual time for an experimental period). This proves that nothing outside the frog's skin interferes with the oxygen consumption.

Some representative experimental results are shown in Table 1. It is seen from column 3 that the total oxygen consumption in μequiv./hr. is often smaller than the number of μequiv. of sodium transported (column 2). The net oxygen consumption is 20–25 per cent of the sodium transported (column 6), that is, for each additional oxygen atom consumed, eight to ten atoms of sodium can be transported. The last column indicates the oxygen consumption in millilitres per gram of the wet weight.

Stapp[5] defined coulomb efficiency as

$$\frac{\text{total coulombs generated by skin}}{\text{coulomb equivalents of total oxygen}}$$

This ratio expresses, as we now know, the amount of sodium transported per gram equivalent of oxygen used. Stapp found in frog skins that were partially short-circuited by means of an external conductor coulomb efficiencies varying from 10 to 65 per cent, and he was surprised at this high value.

Linderholm[2] calculated the coulomb efficiencies from mean values of current and oxygen consumption in a large series of experiments; he arrived at a figure of 82 per cent for the short-circuited skins. This result is not in contradiction with the results

Table 1

Date	Active sodium transport (μequiv./hr.)	Total oxygen consumption (μequiv./hr.)	Net oxygen consumption (μequiv./hr.)	Coulomb efficiency (per cent)	Net oxygen consumption, as per cent of active sodium transport	Oxygen consumption (ml.gm.$^{-1}$hr.$^{-1}$)
March 9	10·8	6·95	2·57	155	23·8	
April 4	6·50	5·33	1·65	122	25·3	0·118
April 5	5·87	7·16	1·42	82	24·3	0·155
April 19	10·0	6·47	2·51	155	25·1	0·163

given in Table 1. These results were observed mainly with skins with a high sodium transport, in some cases obtained by adding mammalian posterior pituitary extract. It may be added that in experiments with skins that were not short-circuited, Linderholm found an average coulomb efficiency greater than 100 per cent.

The present experiments show that more than one equivalent of sodium is transported for each equivalent of oxygen taken up. The coulomb efficiencies observed by Stapp and in some experiments by Linderholm were less than 100 per cent, and this led Linderholm to assume a one-to-one sodium to oxygen relationship. Since, however, the epithelial layer, which is presumably responsible for the sodium transport, represents only one-sixth of the skin weight, such an assumption would require an unreasonably high oxygen consumption in this layer, even if all the oxygen were used for sodium transport.

It is possible that the oxygen consumed by the skin during the control periods (no transport of sodium) may be used for sodium transport when sodium becomes available, the net oxygen consumption being thus only an extra consumption. In this case the amount of oxygen utilized for the transport of one equivalent of sodium will be somewhere between the net consumption and the total consumption. Whether this will fit into the theory advanced by Conway[6] may be a question of interpreting his symbols. The low relative oxygen consumption does, however, suggest that more than one step of the oxidative metabolic cycle is involved in the transport of sodium.

A more detailed report of this work will appear in *Acta Physiologica Scandinavica*.

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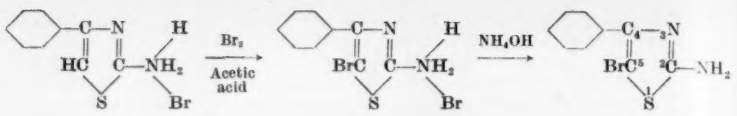
Non-metallic Fungicides



In the course of investigations on the synthesis of 2-amino-4-aryl thiazoles and their derivatives, it was decided to examine their fungicidal properties, as they contain a cyclic grouping, —N—C—S—, which is present in the structure of some of the well-known fungicides[1], and the presence of lipophilic and polar substituents like aryl- and amino-groups in the thiazole nucleus is expected to increase the fungitoxic properties of the thiazoles as reported earlier[2]. The recent use of some thiazole derivatives as fungicides[3] has greatly stimulated work in this direction. The introduction of halogens into the benzene and other aromatic nuclei of various phenolic compounds greatly increases their fungicidal properties[4], and as bromo-derivatives are often more potent than the chloro-compounds, it was thought worth while to introduce bromine into the thiazole nuclei with the hope of augmenting their fungicidal and other activities. In the present communication, seventeen different 2-amino-4-aryl (phenyl; *p*-tolyl; *p*-ethyl phenyl; *p*-methoxy and *p*-ethoxy phenyl; β-phenylethyl and β((*p*-methoxy)phenyl)ethyl; 2 : 5 dimethyl phenyl and 3 : 4 dimethylphenyl; α- and β-naphthyl; *o*- and *p*-hydroxy phenyl; *m*- and *p*-amino phenyl; *p*-bromo phenyl and 2-thienyl) thiazoles have been prepared by the method of King and Hlavacek[5] by allowing different aryl methyl ketones to react with thiourea in the presence of iodine. These compounds have been brominated with bromine in acetic acid medium after protecting the amino-group either by converting it to the hydrobromide salt or by acetylating it. In all these cases bromine entered position 5 of the thiazole nucleus. The position of bromine was ascertained by the inability of such compounds to undergo coupling with diazotized aniline, which usually takes place at position 5[6] if it is free.

All the seventeen bromo thiazoles have been screened for both fungicidal and bactericidal action. For fungicidal assay, the method of Montgomery and Moore[7] was used. *Piricularia oryzae* Cav., the causative organism of rice blast, was used as the test fungus. The compounds 4(*p*-hydroxy phenyl), 4(α-naphthyl) and 4(*p*-bromo phenyl), 5-bromo thiazoles completely inhibited spore germination at concentrations of 20, 20, 22 p.p.m. respectively, and at concentrations of 10, 12, 10 p.p.m., spore germination was only 50 per cent. The unbrominated thiazoles inhibited spore germination at a concentration of 90 p.p.m.

The Rideal–Walker serial drop dilution method was used for the study of the antibacterial activity. The test organism was a 24-hr. culture of *Staphylococcus aureus*. While some of the unbrominated thiazoles were active in 1 : 8,000 (*M.E.D.*) dilution, 4(*m*-amino phenyl), 4(*p*-ethoxy phenyl), 4(α-naphthyl) 5-bromo thiazoles showed activity in 1 : 20,000 (*M.E.D.*) dilution, and 4(β-naphthyl), 4(β-phenyl ethyl) 5-bromo thiazoles showed activity at a dilution of 1 : 15,000.

Details of this work will be published elsewhere. I thank Dr. M. K. Rout, reader in chemistry, for his interest and help in the work, and Mr. S. Y. Padmanavan, mycologist of the Central Rice Research Institute, Cuttack, for supplying the culture of the test fungus for the fungicidal work.

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Potassium Ion Stimulation of Hydrocarbon Oxidation by a Soil *Corynebacterium* sp.

THE oxidation of straight-chain aliphatic hydrocarbons by a soil *Corynebacterium* sp. has been described previously[1]. The present communication demonstrates that the rate of hydrocarbon oxidation by washed suspensions may be stimulated markedly by potassium ions, which, however, have little effect on the oxidation-rate of possible intermediates.

Suspensions of the bacteria were grown either in a synthetic glucose broth deficient in potassium ions, or in nutrient broth, *p*H 7·0, incubated two to three days at 26° C. on a shaking machine. The synthetic medium had the composition 10 gm. glucose, 3·0 gm. ammonium nitrate, 1·5 gm. diammonium hydrogen phosphate, 0·25 gm. magnesium sulphate, 0·1 gm. calcium chloride, trace amounts of ferrous, zinc, cupric, manganese and molybdate ions per litre. The harvested cells were washed once with distilled water, shaken overnight at 26° C. to reduce endogenous respiration, centrifuged and resuspended in distilled water (1 ml. suspension equivalent approximately 1·0 mgm. total cell nitrogen). The hydrocarbons were obtained from L. Light and Co., Colnbrook, England. Respiratory exchanges were measured by the Warburg technique at 27° C. in 0·02 *M* tris (hydroxymethyl) amino methane buffer *p*H 7·0. 0·05 ml. hydrocarbon was added from the side-arm.

The effect of potassium ions (0·0008 *M* final) was tested on the rate of oxidation of *n*-hexadecane, *n*-tetradecane and *n*-decane by suspensions of *Corynebacterium* sp. harvested from potassium-deficient media. There was an initial lag period of low oxygen uptake during which potassium ions caused a slight but consistent inhibition of the oxidation-rate. The lag period varied from 1 to 2 hr., depending upon the hydrocarbon oxidized. There followed a marked stimulation of the rate by the added potassium ions. The respective overall oxygen consumptions in the presence of the C_{16}, C_{14} and C_{10} paraffins were stimulated 231, 108 and 122 per cent by 0·0008 *M* potassium ions in 7 hr. No further stimulation was obtained by adding ten times this concentration of potassium ions. *n*-Octane was oxidized much more slowly, but after 7 hr. a net oxygen uptake of 125 µl. in the presence of potassium was observed, compared with 43 µl. in its absence.

The effect of other monovalent cations on hydrocarbon oxidation by potassium-deficient cells was investigated. 0·0008 *M* ammonium ions, after 6½ hr. incubation, stimulated *n*-hexadecane oxidation even more than potassium ions (225 compared with 168 per cent). Rubidium ions were less effective (138 per cent). Caesium, sodium and lithium ions had no significant effect.

Similar results were obtained with *n*-decane as substrate, except that 0·0008 *M* ammonium ions had no effect upon the oxidation-rate, and rubidium ions only stimulated after 5 hr. incubation. In a separate experiment, however, it was shown that 0·008 *M* ammonium ions, after 4 hr., stimulated *n*-decane oxidation 111 per cent compared with 114 per cent stimulation by an equivalent of potassium ions. Rubidium ions (0·008 *M*) again stimulated only after a lag period (35 per cent in 4 hr.).

The monovalent ions were added as their chlorides. The stimulation achieved is due to the cation, since identical results were obtained with equivalent amounts of potassium chloride, sulphate and nitrate.

Table 1. STIMULATION OF *n*-DECANE OXIDATION BY POTASSIUM IONS USING FRESH AND LYOPHILIZED CELLS OF *Corynebacterium* SP.

Period of ageing cells at 4° C. (days)	Fresh cells			Lyophilized cells		
	Oxygen consumed (µl.)		Percentage stimulation	Oxygen consumed (µl.)		Percentage stimulation
	Decane + 0·008 *M* K^+	Decane only		Decane + 0·008 *M* K^+	Decane only	
0	339	282	20	307	220	40
1	346	287	21	285	159	79
3	335	280	20	270	134	102

Each cup contained cell suspension ≡ 0·52 mgm. cell nitrogen (non-lyophilized cells), or 0·42 mgm. cell nitrogen (lyophilized cells) in 2·5 ml. 0·01 *M* (final) 'tris' buffer *p*H 7·0, incubated at 27° C. for 3¼ hr.; 0·1 ml. *n*-decane was added from the side-arm.

The stimulation of hydrocarbon oxidation by potassium ions may be demonstrated in another way. Lyophilized cells of *Corynebacterium* sp. grown in nutrient broth showed a marked increase in potassium stimulation of *n*-decane oxidation, when aged in 0·025 *M* 'tris' buffer, at 4° C., compared with identically treated cells of the same suspension which had not been freeze-dried (Table 1).

The effect of potassium ions on the rates of oxidation of the aliphatic monohydric alcohols (range, ethanol to *n*-undecyl alcohol) and of the monocarboxylic acids (range, acetic to *n*-decylic acid) by potassium-deficient cells was investigated. 0·0008 *M* potassium ions had no effect upon the oxidation-rates, although identical concentrations of the cation caused a 244 per cent stimulation in 6½ hr. of oxidation of *n*-hexadecane by the same suspension. If the potassium ion stimulation of hydrocarbon oxidation is a direct effect upon one of the enzyme systems involved, then it would appear it must exert its influence before the formation of likely intermediates such as the fatty alcohols and acids. Further work with cell-free extracts is proceeding to this end.

I thank Miss G. Banos for technical assistance.

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Magnetically Induced Vortex for Small-scale Aerated Culture Studies

THE advantages of aerating liquid cultures of bacteria to enhance the yield are well known. The use of sparger aeration techniques on a small scale is subject to certain disadvantages due to difficulties in sterilizing the air supply and controlling the frothing of the medium—particularly when it contains serum.

Aeration by the production of a vortex in the medium has been described by E. B. Chain *et al.*[1]. This method provides a simple means of finely dispersing the air bubbles and at the same time automatically controls frothing. On a small scale such a vortex can easily be induced by means of a magnetic stirrer, thus obviating the necessity for sterile stirrer paddles and shaft seals. No forced air supply is required, the exchange through a conventional cotton-wool plug being sufficient for the organisms so far cultivated.

We have employed this method for the pilot-scale production of suspensions of *Pasteurella septica*,

'Insein' strain[3], for vaccine investigations. 1,200 ml. amounts of 'Tryptose' broth (Difco) at *p*H 7·3 were sterilized in 4-litre boiling flasks, a magnetic stirrer bar being enclosed with the medium. The flasks were inoculated with 1 ml. of an 18-hr. broth culture of the organism and incubated at 37° C. The medium in the flask was rotated by means of a magnetic stirrer at such a speed that a continuous stream of fine air bubbles was dispersed by the rotating stirrer bar. Growth curves based on bacterial dry weights were plotted. The peak of the logarithmic phase of growth occurred at approximately 18 hr., at which point the bacterial dry-weight content of the medium was 0·1556 gm./100 ml.—equivalent to ten times Brown's tube 5. A non-aerated control contained, at this point, 0·0152 gm./100 ml., indicating approximately ten-fold increase in yield due to aeration.

The state of capsulation of the organisms was determined by microscopical examination of films stained by an indian ink/methyl violet method. There appeared to be no decrease in the size of the capsule in such aerated cultures when compared with films made from infected blood.

This method has also been employed for the cultivation of *Asterococcus mycoides* for antigen production. The medium used was 'Tryptose' broth supplemented with 10 per cent yeast extract and 10 per cent pig serum at a *p*H of 7·6.

A. mycoides appears to be highly sensitive to mechanical agitation during the lag phase of cultivation. It was found to be advantageous to incubate the inoculated flasks for 18 hr. before starting the stirrer, otherwise on some occasions no growth took place. A bacterial dry-weight growth-curve estimation showed that the peak of the logarithmic phase of growth occurred at approximately 24 hr. after commencement of aeration. At this point the bacterial dry-weight content of the culture was 0·0368 gm./100 ml. This figure is similar to the mean of 0·0322 gm./100 ml. previously recorded in sparger aerated culture[3].

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A Mutant of *Drosophila* without *Iso*xanthopterine which is Non-Autonomous for the Red Eye Pigments

*Iso*xanthopterine has recently been found in tissues of various anthropods[1,2]. It seems to be a common and regular constituent of normal genotypes of many species. We also found this substance in the following mutants of *Drosophila melanogaster*: *b, bw, ca, car, cd, cl, cn, e, g*[2], *kar*[2], *ltd, lt, lzcl, ma, mah, p, pn*[2], *pr, rs*[2], *se, sed, st, v, w, w*[a], *y*. In certain genotypes such as *w* and *bw*, however, the *iso*xanthopterine disappears from the body[2] during the first days of imaginal life.

By studying the inventory of substances obtained from a new mutant with reddish-brown eyes, we discovered that this genotype of *Drosophila melanogaster* does not at any stage of development contain *iso*-xanthopterine. This biochemically exceptional mutant was isolated from one of our laboratory stocks; for the respective gene we determined the locus 51 ± 1 in the third chromosome. We then searched for known Mendelian eye-pigment factors within this chromosomal region and found that a little-known mutant, *rosy* (*ry*), which was discovered and approximately located by Bridges[3], corresponds phenotypically and genetically with our mutant, for which we now use the term "*rosy*[2]" and the symbol *ry*[2]. The F_1 hybrids *ry*/*ry*[2] have the same reddish-brown eyes as both their parents, and they, too, do not contain *iso*xanthopterine.

Table 1. Fluorometric Values of the Red Pigments of Single Eyes in Arbitrary Units

Exp.	Host	Implant	*n*	Mean and its standard error Host	Implant
I *a*	+ ♀	+	16	27·0 ± 0·75	14·5 ± 0·81
b	+ ♂	+	18	22·3 ± 0·80	12·3 ± 0·55
II *a*	*ry*[2] ♀	*ry*[2]	10	8·3 ± 0·71	6·8 ± 0·59
b	*ry*[2] ♂	*ry*[2]	4	5·25 ± 0·64	5·25 ± 0·48
III *a*	+ ♀	*ry*[2]	10	26·77 ± 0·50	15·0 ± 0·85
b	+ ♂	*ry*[2]	14	23·33 ± 0·75	13·29 ± 0·73
IV *a*	*ry*[2] ♀	+	12	10·25 ± 1·09	7·69 ± 0·71
b	*ry*[2] ♂	+	11	6·91 ± 0·58	5·0 ± 0·47

In addition to the mutant eye colour and the lack of *iso*xanthopterine, there are some further features characteristic of our *rosy*[2] allele. The Malpighian tubes become inflated, and they contain in their lumens large inclusions of a yellow- to orange-coloured excretion material. The viability of our *ry*[2] stock is reduced at 25° C.; 30–60 per cent of the imagines die either before, during or shortly after hatching from the puparium. Thus *ry*[2] behaves as a *P/l* semilethal[4].

The reddish-brown eye-colour is due to a considerable reduction of the red pigments, and in the combinations *cn*/*cn*, *ry*[2]/*ry*[2] or *v*/*v*, *ry*[2]/*ry*[2] the eyes become orange, owing to further lack of the brown ommochrome pigments.

By transplanting eye disks and other larval primordia, we have studied the inventory of fluorescent pigments of *ry*[2] organs after their development in normal hosts (+) and vice versa. Each metamorphosed transplant was chromatographed and its fluorescent substances compared with corresponding organs of the host and untreated controls. In this way the amount of pigment was determined fluorometrically on the chromatographic paper by a method used earlier[5]. A group of representative experiments is summarized in Table 1.

Table 1 shows the following results: (1) A transplanted abdominal eye usually does not form as much red pigment as an *in situ* eye of the same genotype (Exp. I and II). (2) Eye disks of *ry*[2] behave non-autonomously in wild-type hosts (+); they can form as much red pigments as transplanted + eyes in + hosts (Exp. III and I). (3) Transplanted + eyes do not behave autonomously when developing in *ry*[2] hosts; their pigment formation is inhibited by the mutant host (Exp. IV and I).

It was further shown that *ry*[2] eye implants normally become pigmented not only in + hosts but also in *bw, ca, cn, ma, mah, p, rs*[2], *se, w* and *w*[a].

We then found that the (unknown) substance or substances which *ry*[2] host eyes need in order to become normally pigmented can be supplied especially by implanted larval fat bodies and Malpighian tubes of *ry*[+].

A second biochemical character of *ry*[3] also behaves non-autonomously. Implanted Malpighian tubes, fat bodies, testes and eyes from a + donor cause, in *ry*[3] testes, the formation or at least the accumulation of *iso*xanthopterine.

The investigation of the gene-conditioned synthesis of *Drosophila* eye pigments has hitherto been much hampered, since most of the colour mutants behaved autonomously as transplants as well as towards fed or injected substances. Only *vermilion* (*v*) and *cinnabar* (*cn*) could be influenced experimentally, so that an analysis of the genic action of the respective loci on the formation of brown ommochrome pigments became possible (compare the well-known work of Beadle, Ephrussi, Clancy, Tatum, Butenandt and others). With regard to the red pigments, however, no suitable mutant with non-autonomous development was known. Thus the *rosy* mutant provides an approach to a developmental and biochemical analysis. A detailed report of our studies will be published in the *Zeitschrift für induktive Abstammungs- und Vererbungslehre*.

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Chromosomes of the Common Shrew

BOVEY[1] reported that two male specimens of the common shrew (*Sorex araneus* L.), from Switzerland, had a sex-chromosome trivalent at first metaphase of meiosis. He did not examine female chromosomes, so was unable to determine whether the sex-chromosome mechanism was $XY_1Y_2 : XX$ (the female having one sex-chromosome *less* than the male) or $X_1X_2Y : X_1X_1X_2X_2$ (the female having one sex-chromosome *more* than the male). Study of four male and two female shrews collected in Britain confirms the presence of a sex-chromosome trivalent in the male and shows that the female has but two sex-chromosomes (XX).

Three unequal-sized sex-chromosomes are present at metaphase of spermatogonial mitosis (Figs. 2, 5), and these form a trivalent at first prophase and metaphase of meiosis (Fig. 3). These male sex-chromosomes are a large nearly V-shaped chromosome (X), a long rod-shaped chromosome (Y_2) of nearly equal length to the largest arm of X, and a small chromosome (Y_1). In addition, there are two large pairs of approximately V-shaped (metacentric) autosomes, and a number of smaller autosomes. In female bone marrow cells

Fig. 1. Female. Two X-chromosomes and the two largest autosomal pairs. × 2,400

Fig. 2. Male. X-, Y_1- and Y_2-chromosomes and the largest two autosomal pairs. × 2,400

Fig. 3. Male. First metaphase showing the sex trivalent and the largest two autosomal bivalents. × 2,400

(Figs. 1, 4) two X-chromosomes of identical appearance to that of the male, the two large pairs of metacentric autosomes, and the smaller autosomes are present. The acrocentric Y_2 and the short Y_1 are absent in female cells. A similar $XY_1Y_2 : XX$ sex-chromosome system is known in the marsupials *Potorous tridactylus*[2] and *Protemnoden bicolor* (= *Macropus ualabatus*) (Sharman, G. B., unpublished results) and has also been reported in the rodents *Gerbillus pyramidum*, by Matthey[3], and *G. gerbillus gerbillus* by Wahrman and Zahavi[4].

At prophase of meiosis the trivalent of *Sorex* is composed of two parts, one of which shows the same degree of condensation as the autosomes, whereas the other shows precocious prophase condensation like the sex bivalents of other mammals. We thus conclude that the compound X-chromosome has arisen by a reciprocal translocation between an ancestral X-chromosome and one member of a pair of acrocentric autosomes. Assuming permanency of the end segments of chromosomes (telomeres), this calls for a 'two-break' rearrangement. Presumably one break took place in the homologue of Y_2 and resulted in the loss of an almost terminal centromere, whereas the other took place near the end of one arm of the ancestral X-chromosome. The point at which

Fig. 4. Female, *S6*. Photograph of a squash preparation of bone marrow pretreated with hypotonic saline. There are twenty-five chromosomes, ten of which are rod-shaped and show a two-armed as distinct from a four-armed structure. × 2,400

Fig. 5. Male, *S1*. Photograph of a squash preparation of spermatogonium. There are twenty-three chromosomes. Rod-shaped Y_2 overlying metacentric chromosome at 3 o'clock. Four small rods and Y_1 in centre of plate. × 2,400

the broken chromosome ends probably rejoined is indicated by an arrow in Fig. 2. This point can be detected in some mitotic metaphase preparations by the different degrees of condensation of the two types of chromatin making up the compound *X*. The evolution of the XY_1Y_2 system in *S. araneus* thus appears to parallel the evolution of the same type of system in *Potorous tridactylus*[2], where (in contradiction to White's statement[5]) the mode of origin of the multiple system is clear. A comparison of Bovey's figures[1] with the chromosomes of my material indicates that he has mistaken one of the smaller metacentric autosomes for the *X*-chromosome. As is obvious from Figs. 1–5, the *X*-chromosome is among the largest of the set and its origin, as explained above, requires that one of its arms be longer (or at least as long as) the Y_2-chromosome. This is not so in the sex-chromosomes as pictured by Bovey, whose caryograms show the Y_2 (Y_a in his notation) to exceed the combined lengths of both arms of the *X*-chromosome.

The chromosome number in six specimens of *S. araneus* studied varies between twenty-two and twenty-five. The number of sex-chromosomes is constantly two in the females and three in the males, so that autosomal numbers vary between nineteen and twenty-three. The common shrew, therefore, shows cytological polymorphism, which can be explained on the assumption that what White[6] calls "centric fusions" (that is, Robertsonian changes) have occurred between non-homologous acrocentric autosomes. In all specimens examined there are, almost certainly, thirty-six autosomal arms, some of which are represented either by one metacentric or by two acrocentric autosomes. Apart from the observations of Wahrman and Zahavi[4], intrapopulational chromosomal polymorphism in mammalian species does not hitherto appear to have been reported. Five of the six chromosome counts obtained during this survey were, of necessity, determined from bone marrow preparations, the animals having been captured out of the breeding season. This survey will be resumed in the spring, and these and further observations will be fully reported elsewhere.

This study was carried out at the Medical Research Council Radiobiological Research Unit, Harwell, where, through the courtesy of its director, Dr. J. F. Loutit, I was provided with laboratory facilities while receiving financial support from the Nuffield Foundation. I wish to thank Dr. C. E. Ford for helpful supervision and Dr. Dennis Chitty, of the Bureau of Animal Population, Oxford, for collecting one of the specimens used.

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Two Modes of Inheritance of the Short-styled Form in the 'Genus' *Oxalis*

An investigation to find the mode of inheritance of style-length in the tristylic species *Oxalis articulata* Savign., the gardeners' *floribunda*, was begun in 1949 when the genetic situation in *O. valdiviensis* had been established[1,2]. In the latter species inheritance is disomic; there are two linked dominant genes, that for Short being epistatic to Mid, and the long-styled form is the double recessive.

Data obtained from *O. articulata* revealed a different situation, for when a Long and Mid were crossed reciprocally, both plants having one Short parent, Shorts appeared in their progenies as follows:

	L	M	S	Total
L × M	28	56	35	119
M × L	19	51	41	111
	47	107	76	230

Ten Longs from the M × L progeny were crossed to a Short. In the following year, three of these Longs gave only Longs, 360 in all, and seven gave 452 Longs : 495 Shorts, which fits a 1 : 1 ratio (χ^2 is 1·9525 for 1 degree of freedom). Five Mids from the L × M progeny were selfed; one gave only Mids and Longs and four gave a quarter Shorts, altogether 150 out of a total of 561 plants grown (χ^2 is 0·9037 for 1 degree of freedom).

Although the proportion of Shorts obtained from the reciprocal cross first mentioned is more than a quarter ($\chi^2 = 7{\cdot}9362$ for 1 degree of freedom) the occurrence of any Shorts suggests that this form is recessive. Had there been any doubt that some unknown factor was influencing this ratio, it would have been removed by the performance in the following year. These data also show that Longs and Mids can be either homozygous or heterozygous at the *S* locus. Of the fifteen plants tested, four were homozygous where a third were expected. This situation is in complete contrast to that which exists in *O. valdiviensis*. On the other hand, both species are similar in that the short gene, whether dominant as in *O. valdiviensis* or recessive as in *O. articulata*, is epistatic to Mid. It is remarkable that two such different modes of inheritance of the short-style form should exist in the same genus.

O. articulata segregates for pink and white flowers and also has a diluting factor which has no discernible effect on white petals. Linkage of the Short locus and that for pink flower colour has been found. In 1954 eight pink Mids known to be in repulsion (Sp/sP) were crossed to white Shorts (sp/sp). Six of the progenies obtained gave 333 recombinants out of a total of 1,289 plants. The other two progenies were heterogeneous, and, therefore, are not included for the purpose of estimating the recombination fraction. Using the method of maximum likelihood, we find this is $25{\cdot}8 \pm 1{\cdot}2$ per cent.

The situation at the Short locus is similar to that found by von Ubisch[3] in *O. rosea*, although, rather confusingly, she used the dominant symbol for the short allele. She also showed that the loci for short-style and pink flowers are linked with 25 per cent crossing-over. Other species tested in this Department are *O. hirta* L., form *E*, *O. tragapoda* Salter and *O. bowiei* Lindl. These three species have been found to have a dominant Short as in *O. valdiviensis*. The results may be summarized as follows:

Dominant Short	Recessive Short
O. valdiviensis	*O. rosea*
O. hirta L., form *E*	*O. articulata* Savign.
O. tragapoda Salter	
O. bowiei Lindl.	

A more extensive publication elsewhere will be delayed so that inheritance of the Mid form in *O. articulata* may be included. I wish to thank Captain T. M. Salter for collecting and sending the South African species mentioned together with many others, and Sir Ronald Fisher for his constant help and encouragement.

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Moult Adaptation in Relation to Long-distance Migration in Petrels

Meinertzhagen[1] has described in South Greenland seas (*c.* lat. 60° N.) flocks of wing-moulting, and often temporarily flightless, great shearwaters (*Puffinus gravis*) which migrate trans-equatorially northward from their Tristan da Cunha breeding grounds (lat. 37° 6′ S.). He suggests that it "needs to be explained why the Great Shearwater moults in its winter quarters, whilst the Fulmar (*Fulmarus glacialis*) moults while the young are hatching". (The fulmar, of course, breeds locally.)

In the course of a study[2] of the breeding cycle in relation to the trans-equatorial migration of the short-tailed shearwater (*Puffinus tenuirostris*) we have accumulated data that have bearing on the point raised above.

Many widely unrelated species undergo a post-nuptial moult involving the uninterrupted and more or less serial replacement of the feathers of tail, wings, body and head (for example, the rook, *Corvus frugilegus*)[3]. In other species, such as the fulmar, body moult comes first, immediately followed by the shedding of wing-quills[1,4,5].

During our investigation of *P. tenuirostris* on its Tasmanian breeding grounds, we found that all fifty-three sexually mature examples examined in the post-nuptial phase moulted only on the head and body. Although ovulation occurred in November, flight- and tail-feathers were not replaced before the shearwaters departed in April on their long migration into North Pacific and Arctic waters. It was concluded that the annual replacement of the feathers most involved in flight must be delayed until the termination of this long journey.

Examination of the literature showed that this is indeed what happens. *P. tenuirostris* has been collected while moulting its wing- and tail-feathers in northern waters in June and July[6,7]. Further, two other shearwaters of broadly comparable trans-equatorial movement pattern exhibit a similar post-migratory wing moult. Thus, *P. griseus* has been observed moulting in wing and tail in the northern hemisphere summer[8,9] and *P. gravis* (as mentioned above) has been similarly observed by a number of authors[1,10–13]. An especially remarkable divergence in moult-timing probably occurs even between sub-species. Thus, while *P. puffinus mauretanicus* (which breeds in the Balearic Islands and undergoes only a restricted migration or dispersion) carries out the whole of its post-nuptial moult without delay[14], there is a suggestion that *P. p. puffinus* delays the replacement of its flight (but not most of its body) feathers until after crossing the equator to its southern hemisphere 'wintering' grounds[15].

From the above data there emerges clear evidence of the evolution of a moult adaptation related to the migratory requirements of species that undergo a long post-nuptial migratory movement. Moult in all adult shearwaters probably begins during the nesting period; but in trans-equatorial migrants there is a hiatus that allows the retention of the wing- and tail-feathers until after the completion of their post-nuptial journey.

Once the flocks reach their contra-nuptial quarters the moult is completed in a short, sharp burst. The sea is then bestrewn with moulted feathers[7,8] and in the case of one species at least some individuals may be temporarily unable to fly[1]. But the long, arduous journey is now behind them.

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The Langmuir Paradox in Discharge Plasmas

In a recent communication, Gabor, Ash and Dracott have described the detection of oscillations in a positive ion sheath separating a section of wall from the positive column plasma of a low-pressure arc in mercury vapour[1]. The oscillations were studied by passing a pencil of cathode rays through the sheath, and were found to have two main components, one with frequencies of up to about 100 kc./s., and the other with frequencies of the order of 100 Mc./s. We have been investigating the fluctuations of similar discharges by the alternative method of withdrawing oscillatory energy through the main electrodes (anode, cathode) and probes to tuned detectors, and have obtained what appear to be comparable experimental results. Our method does not permit of observation over individual periods of a few hundredths of a microsecond, as does Gabor's, but yields a long-time Fourier analysis of the fluctuations.

Accounts have already been published of the lower-frequency band[2]. It has some nearly monochromatic

components, but consists mostly of 'noise' with an almost flat spectrum of intensity per unit frequency band versus frequency. The latter can be accounted for by the occurrence of pulses of ionization with appropriate time-constant superposed on the main steady ionization in the discharge. It can be largely prevented from reaching a probe by making the latter negative. It originates where sections of the discharge are unstable, particularly in the cathode sheath when this contains a potential minimum[3]. Its presence does not appear essential for maintenance of the discharge.

The high-frequency band has also been found to have a nearly flat spectrum, between about 15 Mc./s., below which it is usually masked by the more intense lower-frequency noise, and 120 Mc./s., the highest frequency we have studied. The energy which can be withdrawn is almost independent of probe potential, and roughly of the order of magnitude to be expected from the random thermal motion of electrons in the plasma; we have not been able to make an exact comparison with the electron-thermal noise, owing to uncertainty as to what equivalent resistance is to be attributed to a plasma in this connexion. This high-frequency 'noise' may be related to the sheath oscillations reported by Gabor *et al.*, the fields of which have maximum amplitude at the wall, that is, in our case, the probe surface. They remark that both the amplitude and the frequency of the oscillations were variable, particularly the former, and that the oscillations were not necessarily coherent over an area of wall sheath; the frequency spectrum will therefore be broad, although it is not certain that it would be as flat as we have found the high-frequency 'noise' spectrum to be.

It seems to us uncertain that a 'Langmuir paradox' necessarily arises near a hot cathode, where fast primary electrons from the thin space-charge sheath on this electrode are present. These may regenerate the high-energy tail of the main plasma group of electrons in two ways if this is being lost to the wall: first, by collisions with the gas molecules, and secondly and possibly more efficiently, by means of high-frequency oscillations in the primary beam and volume of the plasma. Whatever the mechanism of these oscillations may be, they are definitely associated with considerable randomizing of the primary beam in both energy and direction[4].

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Isosterism and Molecular Fourier Transform: Crystal Structure Determination of 2-4-Dihydroxybenzoic Acid as related to that of 2-Hydroxy-4-aminobenzoic Acid

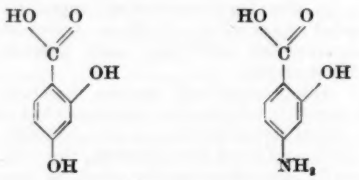
Isosteric organic compounds, that is, compounds differing only in the nature of one more atom or substituent groups, often crystallize in quite different lattices. Using the older X-ray techniques, knowledge of the crystal structure of one member of an isosteric pair may thus be of little help in solving the structure of the other member; but the new Fourier transform techniques[1] allow the investigator to take full advantage of such a situation. This is especially easy if the molecules happen to be planar and centrosymmetric, or if they associate to form centrosymmetric groups.

Table 1

	a	*b*	*c*	*α*	*β*	*γ*	*Z*	Space group
2-4-Dihydroxybenzoic acid*	7·05	9·67	11·81	98° 50′	109° 28′	91° 43′	4	C_i^1–$P\bar{1}$
2-Hydroxy-4-aminobenzoic acid	7·28	3·82	25·33	—	103°	—	4	C_s^4–$AP2_1/c$

* A number of water molecules ranging between ½ and 3 per mole of compound is given in the literature (see "Beilstein", **10**). We have, however, been unable to find any water in the crystal. This result has been confirmed by analysis, and it seems likely that the loss of weight due to the easy decarboxylation of this compound might be responsible for the erratic results reported in the literature.

An example of this method of analysis is the determination of the crystal structure of 2-4-dihydroxybenzoic acid (I), a compound which is isosteric with 2-hydroxy-4-aminobenzoic acid (II).



(I) (II)

The crystal structure of the latter had already been established[2] when it was decided to investigate the structure of the former. The unit cells of these two compounds are quite different (Table 1), (II) being monoclinic and (I) triclinic. Structure II had been found to contain centrosymmetric dimers linked together by hydrogen bonds. The same pairing was therefore also expected to occur in (I), in which case the space group was likely to be $P\bar{1}$. This was confirmed, first by the absence of any piezoelectric effect, and later by plotting the intensity distribution of $0kl$ reflexions; this distribution was of the hypercentric type[3], actually indicating the presence of centres of symmetry additional to that required by the space group $P\bar{1}$. As there are four molecules in the unit cell, this implies two centrosymmetric dimers related by the centre of symmetry of the space group.

To find the arrangement of the molecules in the unknown structure (I), the Fourier transform of the known molecular structure (II) was calculated by sampling the electron density distribution projected on 010 and correcting it for the tilt of the dimer with respect to this plane. Two weighted reciprocal lattice sections were now prepared from the $h0l$ and $0kl$ intensities of (I). With the help of a simple device (described elsewhere by one of us[4]) the calculated transform was projected in turn on each of these

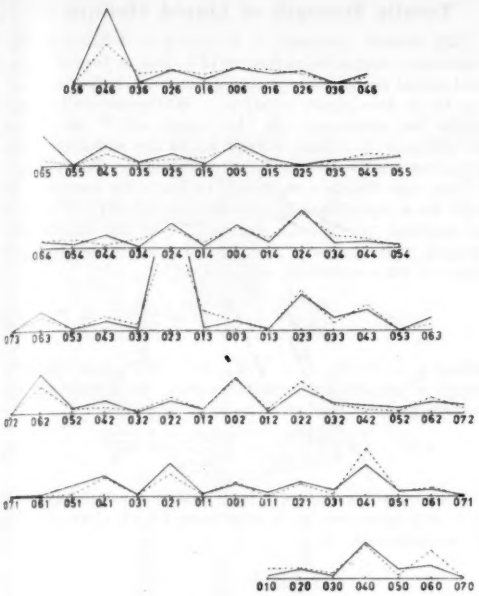


Fig. 1. Comparison between experimental amplitudes F_{obs} (dotted line) and sampled values of the Fourier transform corrected by the fringe function (full line)

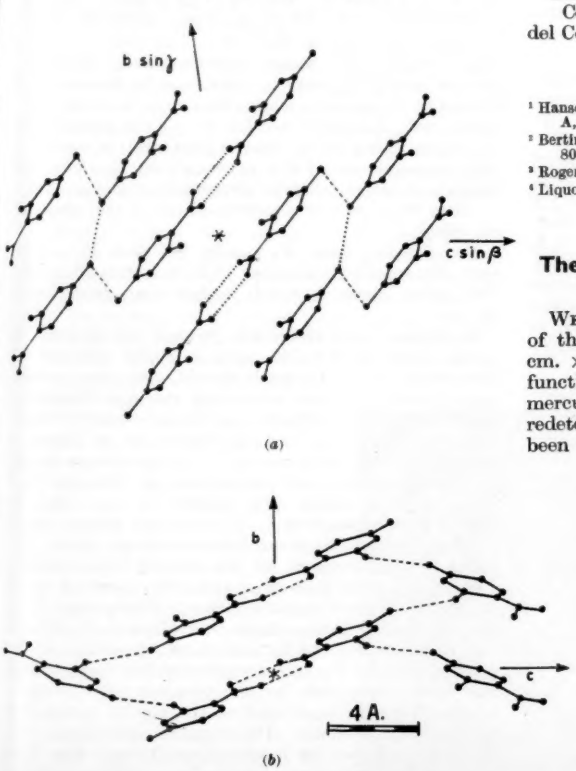


Fig. 2. Schematic drawing of the packing of molecules in the unit cell of (*a*) 2-4-dihydroxybenzoic acid and (*b*) 2-hydroxy-4-amino-benzoic acid

sections, and molecular orientations giving the best fit were found by trial. At the same time the nodes of the fringe function relating the centres of the two dimers could be recognized from a characteristic trend of the 0*kl* reflexions, giving these centres the approximate co-ordinates of $0\ \frac{1}{4}\ 0$; $0\ -\frac{1}{4}\ 0$. On further refinement the centres had to be displaced slightly from these positions. After this had been done, and the sampled transforms had been corrected by a suitable fringe function, the agreement shown in Fig. 1 was obtained for the 0*kl* reflexions, which may be considered good enough to establish the packing of the molecules in the unit cell with a fair degree of accuracy (Fig. 2).

The packing turns out to be quite different in the two isosteric compounds, despite their common tendency to form hydrogen-bonded pairs. Further analysis of the differences between the two structures was not pursued, because considering the similarity in their physico-chemical properties, such differences would be expected to be very small.

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[2] Bertinotti, F., Giacomello, G., and Liquori, A. M., *Acta Cryst.*, **7**, 808 (1954).
[3] Rogers, D., and Wilson, A. J. C., *Acta Cryst.*, **6**, 439 (1953).
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The First Townsend Ionization Coefficient for Hydrogen

We have completed independent measurements of the first Townsend coefficient α/p_0 (ionizations/cm. × mm. mercury at 0° C.) for hydrogen as a function of the parameter E/p_0 (volts/cm. × mm. mercury at 0° C.). In view of the several partial redeterminations of this quantity that have recently been reported, we feel that early mention of our results may be of interest.

The results are shown in Fig. 1, where α/p_0 is plotted against p_0/E. Those by Rose are taken at pressures $0{\cdot}5 < p < 45$ mm. mercury, and those by De Bitetto and Fisher at pressures of 100 and 200 mm. mercury. Throughout the range $0 < p_0/E < 0{\cdot}045$, α/p_0 can be represented within the experimental error (± 2 per cent) by the function:

$$\alpha/p_0 = 5{\cdot}1 \exp(-139\, p_0/E)$$

Outside this range, the curve passes through the following points: (0·050, $4{\cdot}6 \times 10^{-3}$); (0·055, $2{\cdot}1 \times 10^{-3}$); (0·060, $8{\cdot}9 \times 10^{-4}$); (0·065, $3{\cdot}6 \times 10^{-4}$).

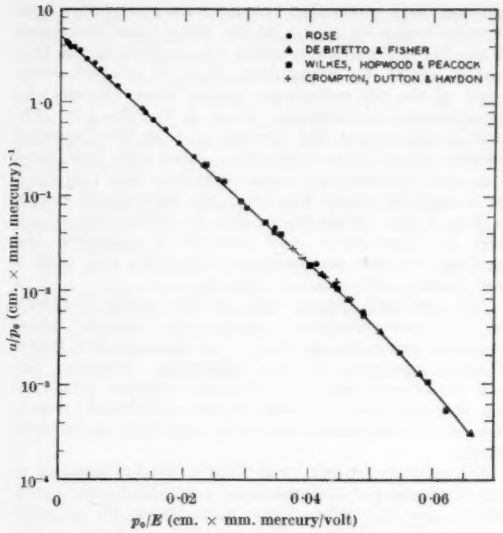

Fig. 1. The first Townsend coefficient α/p_0 (ionizations/cm. × mm. mercury at 0° C.) for hydrogen as a function of p_0/E (mm. mercury at 0° C. × cm./volt)

It is interesting to compare our results with those already published. Before doing so, it is essential that all be reduced to the same temperature, such as 0° C. In this connexion, it is unfortunate that the temperature at which the results are meant to apply is not always explicitly stated.

In the range $0 < p_0/E < 0{\cdot}025$, the present results agree fairly well with those of Ayres[1]; but at larger p_0/E, his results lie substantially above ours. At $p_0/E = 0{\cdot}06$, for example, Ayres gives $\alpha/p_0 \approx 1{\cdot}8 \times 10^{-2}$. Observations taken by Hale[2] extend throughout the range $0 < p_0/E < 0{\cdot}04$; they are higher than ours at both extremes, and lower by a factor $\approx 1{\cdot}8$ at $p_0/E = 0{\cdot}01$. We find excellent agreement with the recent results reported by Wilkes, Hopwood and Peacock[3] ($0{\cdot}027 < p_0/E < 0{\cdot}062$), and also with those reported by Crompton, Dutton and Haydon[4] ($0{\cdot}037 < p_0/E < 0{\cdot}046$). However, results at higher p_0/E reported by Crompton, Dutton and Haydon in an earlier communication[5] lie considerably above ours.

Complete discussions of these and other related observations will appear elsewhere. That part of the work performed at New York University has been supported by the U.S. Office of Naval Research.

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D. J. De Bitetto
L. H. Fisher

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New York 53, N.Y.
March 6.

[1] Ayres, T. L. R., *Phil. Mag.*, **45**, 353 (1923).
[2] Hale, D. H., *Phys. Rev.*, **55**, 815 (1939). See also Loeb, L. B., "Basic Processes of Gaseous Electronics", 691 (Univ. Calif. Press, 1955).
[3] Wilkes, A., Hopwood, W., and Peacock, N. J., *Nature*, **176**, 837 (1955).
[4] Crompton, R. W., Dutton, J., and Haydon, S. C., *Proc. Phys. Soc.*, B, **69**, 1, (1956).
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Tensile Strength of Liquid Helium II

The tensile strength of a liquid is defined as the maximum negative pressure (P) that a liquid in an isothermal metastable state can sustain before returning to a two-phase system. Mathematically, this might be expressed as the value of P at which $(\partial P/\partial V)_T = 0$, where V represents the volume of the liquid at temperature T. According to Temperley[1], if Van der Waals's equation of state be assumed to hold for a liquid and the condition that $(\partial P/\partial V)_T = 0$ be applied, the tensile strength may be calculated. Benson and Gerjuoy[2], in working with the reduced form of this equation, arrived at:

$$\varphi^3 - \frac{9}{4\theta}\varphi^2 + \frac{3}{2\theta}\varphi - \frac{1}{4\theta} = 0 \qquad (1)$$

where $\varphi = V/V_c$, $\theta = T/T_c$, $\pi = P/P_c$ and the subscript c stands for critical value, by applying the condition:

$$\frac{V_c}{P_c}\left(\frac{\partial P}{\partial V}\right)_T = \left(\frac{\partial \pi}{\partial \varphi}\right)_\theta = 0 \qquad (2)$$

Values may be assigned to θ and the resulting cubic in φ will give rise to a real root which may in turn be substituted in

$$\pi_{\text{min.}} = \frac{3}{\varphi^2} - \frac{2}{\varphi^3}.$$

to give reduced values of the tensile strength.

Consider, for example, the case of nitrogen, which has $T_c = 126{\cdot}06°$ K. and $P_c = 33{\cdot}5$ atm. According to equations (1) and (2), the tensile strength should be about 109 atm. at 69·3° K. This value is much higher than that found experimentally both by Misener and Hedgcock[3] in 1953, and by Misener and Hébert in the present work. However, as Temperley points out, this could be due to (*a*) the presence of impurities in the liquid, (*b*) the possibility of variation with temperature of the constants in the Van der Waals's equation, that is, departure of the equation of state from a true representation of the state of the liquid.

For helium, with $T_c = 5{\cdot}26°$ K. and $P_c = 2{\cdot}26$ atm., the tensile strength at 1° K. becomes 25·9 atm. This value again is much higher than that found by us.

As Misener and Hedgcock pointed out in 1953, it would seem reasonable that a static method of measuring tensile strength should give rise to true values, since these are essentially static in character. Accordingly, a modification of their bellows arrangement, which in turn was an adaptation of Vincent's apparatus[4], was constructed. The apparatus shown in Fig. 1 was the working section at the end of a $1\frac{1}{4}$-in. german silver tube suspended in a double Dewar flask arrangement. The circular plates, 4 and 5, along with their three interconnecting rods, provided a rigid support for the top of both bellows. Three more brass rods fixed the lower plates 1 and 2 so that they could move together. When liquid from the innermost Dewar flask was allowed to fill the top bellows, it could be sealed off by means of the needle valve 6. The latter was controlled from outside the Dewar assembly by the rotation of a vertical, hollow Monel tube welded at the top to a stainless steel threaded shaft. The required seal about this shaft was effected by means of an O-ring. Gas from a source at controlled pressure was fed through the Monel tube 7 into the lower bellows. As the pressure

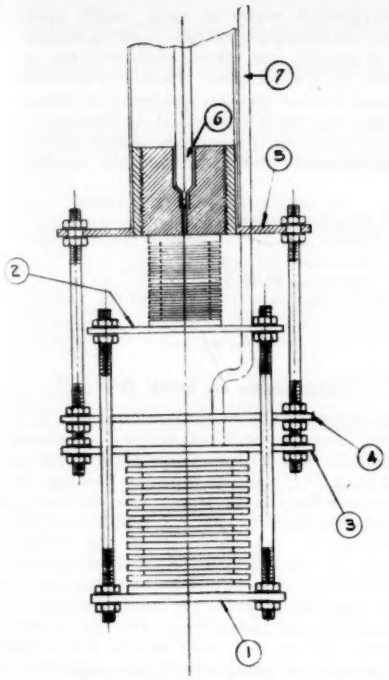

Fig. 1. Pressure-loaded bellows apparatus for tensile strength of liquids

was slowly increased, the level of 2 remained stationary until the maximum negative pressure on the liquid in the upper bellows was reached. Beyond this pressure, plate 2 suddenly moved downwards as observed through the telescope of a cathetometer. The value of this maximum pressure was taken to be the tensile strength of the liquid in the upper bellows.

Since the values obtained in the readings of the gas supply were the pressure values above zero-level on the lower bellows, the problem of determining the effective cross-section of each bellows was of importance. Proceeding in a fashion quite similar to that of Vincent, a load F was attached to the lower bellows, the upper bellows was left open to atmospheric pressure, and the load vs. extension found to be 1·37 kgm./mm. Next, gas under known pressures replaced the load and a calibration of pressure P vs. extension gave approximately 0·16 kgm./cm.²/mm. Obviously the effective cross-section A, from F/P, gave 8·56 cm.². As this value corresponded fairly closely to that calculated from the mean outer and inner radii of the bellows (8·73 cm.), it was assumed that for purposes of the present experiment, the calculated values of the effective cross-section of the upper bellows would be correct. It followed then that the excess pressure applied to the lower bellows, multiplied by 1·95, would give the required values of the tensile strength.

As a preliminary experiment, the tensile strength of liquid nitrogen was measured between 64° K. and 76° K. The tensile strength increased with decreasing temperature and the numerical values were substantially in agreement with those found by Misener and Hedgcock, namely, about 3·5 atm. at 71° K.

In liquid helium II at a number of temperatures between 2·147° K. and 1·092° K., no 'break' in the motion of the upper bellows could be observed. As soon as the working pressure was applied, the bellows began to elongate. The rate of elongation was too large to be accounted for by any possible 'film flow' through the closed needle valve. It is concluded, therefore, that if there is any tensile strength at all for liquid helium II, its value as measured by this bellows method is less than 0·3 atm.

We wish to thank the Physics Department of the University of Toronto for the use of the facilities of its Low Temperature Laboratory for this investigation. We would like to thank particularly Dr. H. Hallett and his staff, both for their encouragement and their assistance during the experimental work.

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[1] Temperley, H. N. V., *Proc. Phys. Soc.*, **59**, 199 (1947).
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Examination of Fossil Coccoliths in the Electron Microscope

Recently, the use of the electron microscope in investigating the form of fossil coccoliths has been reported by Deflandre and Fert[1], and a preliminary revision of the taxonomy has been given by Braarud, Deflandre, Halldal and Kamptner[2]. The published electron micrographs show little more than the outline of the coccoliths and must be supplemented by examination at lower magnifications with the optical microscope. This unsatisfactory situation is due to the coccoliths being opaque to the electron beam. The difficulty has been overcome by examining shadowed replicas of the coccoliths, which give

Fig. 1

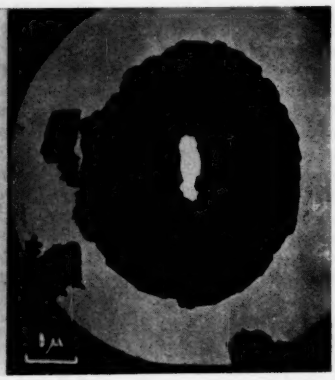

Fig. 2

excellent information about the relief as well as the outline of the coccoliths. The accompanying illustrations compare a shadowed replica (Fig. 1) with a similar coccolith photographed in the transmitted beam (Fig. 2).

The method used in preparation is similar to the silica transfer technique applied by Hall[3] to the study of protein crystals. The replicas of coccoliths were made by dispersing coccoliths, obtained by scraping the rock, in distilled water and supporting this dispersion on a 'Formvar' film. The whole was then coated with a thin evaporated carbon film and the 'Formvar' dissolved in acetone. Finally, the coccoliths were removed with dilute hydrochloric acid and the remaining replica shadowed with gold–palladium.

The method has been applied to coccoliths from the White Band of the Kimmeridge Clay of Kimmeridge, Figs. 1 and 2 being of the dominant coccolith type present. The structure of spirally arranged calcite crystals and central perforation is clearly seen in Fig. 1. It is felt that adequate descriptions of coccoliths should require similar illustration, and that re-examination of existing types by this technique is imperative to establish a satisfactory classification.

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March 2.

[1] *C.R. Acad. Sci., Paris*, **234**, 2100 (1953).
[2] *Micropalæontology*, (1), **2**, 157 (1955).
[3] *J. Biol. Chem.*, **185**, 45 (1950).

Modification of the Bulk Mechanical Properties of Water by Complex Formation in Dilute Solution

A solution of 75 per cent aqueous glycerol shows considerable viscosity (six times that of water) but no structure, so that small bubbles rise to the surface slowly but at a rate predictable from Stokes's law. A 0·07 per cent solution of agar, on the other hand, is only about 4 per cent more viscous than water; but eddies in it are destroyed as rapidly as in the glycerol. Air bubbles rise to the surface in characteristic jerks, and if small enough become trapped. Clearly a certain critical stress has to be exceeded in order to break the molecular framework.

It has now been found that a solution of 0·01 per cent cetyl trimethyl ammonium bromide and 0·005 per cent β-naphthol, added in that order to tap water, resembles the above-mentioned agar solution in its mechanical properties. Its viscosity is only about 2 per cent greater than that of water, eddies are rapidly destroyed and bubbles become trapped. A new feature, however, is the considerable elasticity shown, so that an eddy is not simply damped out but is reversed. Most of the life of a swirl set up in volumes of 500 ml. or less is, in fact, spent in motion in the reverse sense to the initial. With c as the concentration of cetyl trimethyl ammonium bromide in p.p.m., the β-naphthol being at $c/2$ throughout, and t the time in seconds before motion first stops, it was found that the relation $\log t = 0{\cdot}42 + 28/c$ was obeyed between $c = 50$ and 500. The size of the eddy was defined by using 50 ml. of solution in a bottle of 4·3 cm. internal diameter, a rapid swirl being timed with a stop-clock.

When distilled water is used, more material is required, the efficiency of tap water (London) being part of a general salt effect, probably due to anion adsorption by the complex. Details of the chemistry of this and similar systems are being submitted elsewhere, but the easily controlled 'thickening' of large volumes of water in this manner should be of interest in hydrodynamic and sedimentation studies.

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"Zoonoses in East Africa"

In the report of the recent conference in Kampala, Uganda, "Zoonoses in East Africa"[1], I was quoted as suggesting that *Trypanosoma rhodesiense* had developed from *Tr. brucei* by repeated passages through *Glossina pallidipes*. My thesis was, in fact, almost the exact opposite of this. I emphasized that all the evidence so far shows that the property of infectivity to man which alone distinguishes *Tr. rhodesiense* from *Tr. brucei* is an extremely stable one and that there has never been a known case of interconversion of these two. On the other hand, I pointed out, in any area where *Tr. rhodesiense* had appeared, either it could be traced to direct introduction by infected human beings from a known source, or the other human infective 'species', *Tr. gambiense*, had been known to be present in the area for some time.

I stressed the association of *Tr. gambiense* with the *palpalis* group of *Glossina* and of *Tr. rhodesiense* with the *morsitans* group and indicated that *G. pallidipes* was consistently present in areas where *Tr. rhodesiense* had appeared some time after *Tr. gambiense*. There are several areas in which, though the appearance of *Tr. rhodesiense* might conceivably have been due to direct transport, it also might have been due to the conversion of *Tr. gambiense* into the more virulent form, *Tr. rhodesiense*. Such areas are Busoga in Uganda, Buvuma Island in Lake Victoria, Uganda, Central Nyanza in Kenya and North Mara in Kenya. *G. pallidipes* occurs in all these areas. Further, *Tr. rhodesiense* is believed to have originated from the Luangwa Valley in Northern Rhodesia at the end of the first decade of this century, where *Tr. gambiense* was known to have been introduced in the previous two or three years. This area is one of the largest in eastern Africa of a mixed population of *G. pallidipes* and *G. morsitans*.

At the Kampala conference I put forward the hypothesis that *Tr. rhodesiense* has always originated from *Tr. gambiense* and made the tentative suggestion, which is supported by small pieces of other evidence, that the conversion to the more virulent human infective form may have been due to repeated transmission by *G. pallidipes*.

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Tororo, Uganda.

[1] Daves, J. N. P., *Nature*, **177**, 406 (1956).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, May 22

WRIGHT-FLEMING INSTITUTE OF MICROBIOLOGY (at St. Mary's Hospital Medical School, London, W.2), at 5 p.m.—Prof. F. W. Rogers Brambell: "Transmission of Passive Immunity"* (Almroth Wright Lecture).

Tuesday, May 22—Friday, May 25

TEXTILE INSTITUTE (in the Winter Gardens, Blackpool)—Conference on "New Yarns and Fabrics".

Wednesday, May 23

ROYAL SOCIETY OF MEDICINE, ENDOCRINOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Annual General Meeting; followed by a discussion—"Dwarfism and Some Nutritional Factors". Opening Speaker: Prof. A. C. Frazer, followed by Dr. C. E. Dent and Dr. S. H. Taylor.

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. F. M. Martin: "Home Background and Selection for Secondary Education".*

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. K. Froome: "The Measurement of the Velocity of 'Light' by Electronic Methods".

SOCIETY FOR ANALYTICAL CHEMISTRY (joint meeting with the FOOD GROUP of the SOCIETY OF CHEMICAL INDUSTRY, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Scientific Papers.

Thursday, May 24

BRITISH INSTITUTE OF RADIOLOGY, incorporated with the RÖNTGEN SOCIETY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 8 p.m.—Annual General Meeting. 8.30 p.m.—Ordinary Meeting, followed by Prof. F. W. Spiers: "Radioactivity in Man and His Environment" (Presidential Address).

Thursday, May 24—Monday, May 28

BRITISH MYCOLOGICAL SOCIETY (at Flatford Mill)—Spring Foray.

Friday, May 25

BIOCHEMICAL SOCIETY (at Rothamsted Experimental Station, Harpenden, Herts), at 10.45 a.m.—Scientific Papers.

SOCIETY FOR ANALYTICAL CHEMISTRY, PHYSICAL METHODS GROUP (joint meeting with the PHOTOELECTRIC SPECTROMETRY GROUP, in the Physical Chemistry Laboratory, South Parks Road, Oxford), at 2.30 p.m.—Meeting on "Nuclear and Para-Magnetic Resonance".

BRITISH PSYCHOLOGICAL SOCIETY, EDUCATION SECTION (at the University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Mr. H. E. O. James: "Ethnic Prejudices and their Reduction by Educational Means".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Cyril S. Smith: "The Structure of Metals as Seen Under the Microscope".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

TRANSLATOR/ABSTRACTOR (with a knowledge of engineering subjects and ability to translate accurately and speedily from at least two foreign languages) AT THE CENTRAL ELECTRICITY AUTHORITY HEADQUARTERS, London, S.E.1—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. AE/809 (May 25).

LECTURER (with a first- or second-class honours degree in chemistry, and special qualifications in physical chemistry) IN THE SCHOOL OF CHEMISTRY—The Director, Robert Gordon's Technical College, Aberdeen (May 26).

SENIOR LABORATORY TECHNICIAN FOR WORK IN THE CHEMISTRY, PHYSICS AND BIOLOGY LABORATORIES—The Secretary, Paddington Technical College, Saltram Crescent, London, W.9 (May 26).

RESEARCH ASSISTANT (with special qualifications in physical chemistry, and preferably previous experience in some branch of polymer science) IN THE DEPARTMENT OF CHEMISTRY—The Registrar, The University, Manchester 13 (May 28).

PHYSICISTS (2) (one with experience in electronics and the other in radiotherapy), to work in a laboratory engaged in experimental and routine work for the medical staff—The House Governor, King's College Hospital, Denmark Hill, London, S.E.5 (May 29).

DEPARTMENTAL DEMONSTRATOR IN CYTOLOGY, and a RESEARCH OFFICER IN CYTOLOGY—Prof. C. D. Darlington, Botany Department, The University, Oxford (May 31).

OPPENHEIMER GEOLOGICAL FELLOWS (suitably qualified graduates of recognized universities and institutions) IN THE INSTITUTE OF AFRICAN GEOLOGY—The Registrar, The University, Leeds 2 (May 31).

RESEARCH ASSISTANT to take charge of Electron Microscopy (including electron diffraction)—Prof. R. M. Barrer, F.R.S., Imperial College, London, S.W.7 (June 1).

OSBORNE REYNOLDS RESEARCH FELLOW (with experience of research in hydraulics and capable of independent work) IN ENGINEERING—The Registrar, The University, Manchester 13 (June 2).

PHYSICIST OR MATHEMATICIAN (with a first- or second-class honours degree or equivalent, and preferably with a good knowledge of physical principles underlying engineering design) at a Ministry of Supply Research and Development Establishment near Sevenoaks, Kent, for general physico-mathematical work in relation to the performance and instrumentation of armament components—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.163/6A (June 2).

PHYSICIST (with a good honours degree or equivalent) at the National Coal Board's Coal Survey Laboratory in Cardiff, to initiate studies of the physical and mechanical properties of South Wales coal seams—The National Coal Board, Staff Department, Hobart House, London, S.W.1, quoting SS/266 (June 2).

ASSISTANT LECTURER IN MATHEMATICS—The Registrar (Room 9, O.R.B.), The University, Reading (June 4).

LECTURER OR ASSISTANT (Grade B) (with teaching and research experience) IN GEOLOGY up to B.Sc. (Special) standard—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (June 4).

RESEARCH ASSISTANT IN CHEMISTRY (Organic) in connexion with a grant from the British Empire Cancer Campaign Committee, for work on the organic chemistry of nucleotides—The Registrar, The University, Manchester 13 (June 4).

ASSISTANT LECTURER OR LECTURER (with special interests in petrology) IN THE DEPARTMENT OF GEOLOGY—The Registrar, University College, Singleton Park, Swansea (June 5).

SENIOR LECTURER (with a research interest in a branch of applied mathematics) IN MATHEMATICS—The Secretary, Royal Technical College, Glasgow (June 6).

LECTURER IN BACTERIOLOGY—The Secretary of University Court, The University, Glasgow (June 9).

SHELL STUDENTS IN CHEMICAL ENGINEERING—The Registrar, King's College, Strand, London, W.C.2 (June 9).

TUTORIAL RESEARCH STUDENT IN MATHEMATICS (pure or applied)—The Principal, Royal Holloway College, Englefield Green, Surrey (June 9).

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (June 11).

UNIVERSITY LECTURER (preferably specialized in statistics) IN MATHEMATICS—The Secretary of the Appointments Committee of the Faculty of Mathematics, The Arts School, Bene't Street, Cambridge (June 13).

SESSIONAL LECTURER (preferably specialized in historical, cultural and Eurasian geography) IN THE DEPARTMENT OF GEOGRAPHY—The Chairman, Department of Geography, McMaster University, Hamilton, Ontario, Canada (June 15).

TECHNICIAN IN THE DEPARTMENT OF ZOOLOGY—The Registrar, University College of Wales, Aberystwyth (June 15).

LECTURER IN PSYCHOLOGY—Joint Clerk to the University Court, College Gate, St. Andrews (June 16).

LECTURER IN MATHEMATICS at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (June 23).

ASSISTANT LECTURER OR LECTURER IN THE DEPARTMENT OF ZOOLOGY—The Registrar, University College of Wales, Aberystwyth (June 30).

PLANT PHYSIOLOGIST; STATISTICIAN (Biometrician); ASSISTANT SYLVICULTURIST; and an ASSISTANT ENTOMOLOGIST in the Wattle Research Institute of the University of Natal—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, June 30).

SCIENTIFIC ASSISTANT (with some knowledge of biological, preferably horticultural, research and the ability to make abstracts in clear English from several foreign languages)—Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent (June 30).

WAITE CHAIR OF AGRICULTURAL CHEMISTRY—The Registrar, University of Adelaide, Adelaide, South Australia (June 30).

LECTURER (with British university qualifications or equivalent, and some experience in teaching geology in a university department of geology and geography) IN GEOLOGY, at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, July 15).

DIRECTOR (with wide research and administrative experience and ability to co-ordinate research in the various divisions of the Institute) OF THE CENTRAL ELECTRO-CHEMICAL RESEARCH INSTITUTE, Karaikudi, South India—High Commission of India, Establishment Department, Aldwych, London, W.C.2, quoting 4/104A (July 22).

RESEARCH ASSISTANTS (2) (with a good honours degree in physics and adequate research experience) IN THE DEPARTMENT OF PHYSICS, to undertake research on the preparation and properties of infra-red emitting phosphors, under the direction of the Head of the Department—The Registrar, The University, Hull (July 31).

ASSISTANT MASTER (with a good honours degree) TO TEACH PHYSICS up to advanced and scholarship levels—The Headmaster, Nottingham High School, Nottingham.

BACTERIOLOGIST to assist with the control and investigation of sterile procedures in the Blood Products Laboratory—The Secretary, Lister Institute, Elstree, Herts.

DIRECTOR (with at least a second-class honours degree, or equivalent, with extensive experience in any branch of freshwater biology, biochemistry or soils chemistry) OF THE FISH CULTURE RESEARCH AND TRAINING INSTITUTE, Malacca, to be responsible for the overall administration of the Institute and for the direction of the research programme including research into the fundamental processes underlying pond culture, genetics, physiology of breeding, etc.—Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. BCD.65/23/02.

EXPERIMENTAL PHYSICIST (preferably with a degree in physics or mathematics and previous laboratory experience, or at least G.C.E. advanced level in science subjects, or equivalent), to take charge of

the construction and operation of a neutron velocity selector for the new research reactor DIDO—Establishment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting Ref. 546/34.

Lecturer in Aerodynamics—Head of the Aeronautics Department, Imperial College, London, S.W.7.

Lecturer in Inorganic Chemistry and a Lecturer in Organic Chemistry, at the Wolverhampton and Staffordshire Technical College—Clerk to the Joint Education Committee, Education Offices, North Street, Wolverhampton.

Lecturer (with a good honours degree and able to prepare students for the B.Sc. (Special, London, External) and A.R.I.C. examinations) in Organic Chemistry—Clerk to the Governors, Luton and South Bedfordshire College of Further Education, 63–69 Guildford Street, Luton, Beds.

Lecturer (with a good honours degree and teaching experience) in Education—The Principal, The College, Chester.

Lecturer (with a special interest in organic chemistry, and with research experience) in Chemistry (Ref. S.1); and an Assistant (Grade B) (preferably with teaching experience) in Chemistry (Ref. S.2)—The Principal, Hatfield Technical College, Roe Green, Hatfield, Herts.

Lecturer (with good academic qualifications and experience in the food industry) in Food Science—The Secretary, Royal Technical College, Glasgow.

Master (with a good honours degree) to teach Mathematics to advanced and scholarship levels, with some subsidiary physics—The Headmaster, Queen Elizabeth's Grammar School, Blackburn.

Metallurgist or Physicist (with an honours degree in metallurgy, physics or related subject) for research in problems of liquid metals, intermetallic compounds, and alloy transformation phenomena as they are related to behaviour in nuclear reactors—Prof. J. G. Ball, Department of Metallurgy, Imperial College, London, S.W.7.

Physicist or Engineer (with a first- or second-class honours degree or equivalent in physics or engineering, and considerable research and development experience in the instrument electronics field or related systems of engineering in the aircraft industry), at the Royal Aircraft Establishment, Farnborough, Hants, to lead a small team on the assessment of guided weapons systems, with particular concern for radar and guidance aspects—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.176/6A.

Scientific Officers (with a first- or second-class honours degree, and preferably research experience) in the General Physics Division, for research on controlled thermonuclear reactions—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting Ref. 532/34.

Senior Physics Master—The Headmaster, Ellesmere College, Shropshire.

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